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## Contents

Issue: 1

1. **Assessment of socioeconomic and environmental impact of COVID-19 in Pakistan** **53-70**  
**Authors**  
Maria Shahzadi  
Muhammad Bilal
2. **Sustainable urbanization and their challenges in developing countries** **71-78**  
**Author**  
Mudessir Temam Imamu
3. **Working from home and employee performance in the new normal** **79-90**  
**Author**  
Dr FOGBONJAIYE, Seun Samuel
4. **Profitable business ideas in J&K: an overview** **91-94**  
**Author**  
Anzar Hussain Shah
5. **Environmental protection: The use of biosorption of nickel and copper by camel foot (*piliostigma thonningii*) pod in elimination of heavy metals from simulated wastewaters** **95-122**  
**Author**  
Omimakinde E.A.  
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## Assessment of socioeconomic and environmental impact of COVID-19 in Pakistan

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### ABSTRACT

COVID-19 had a detrimental effect on Pakistan, with an estimated 34 percent reduction in employment and a 42 percent decrease in overall income. It was estimated that COVID-19 would cause an economic loss of almost 10% (1.1 trillion PKR) in Pakistan by the end of 2021. The enormous consequences of the epidemic on all aspects of life have transformed the ways of a typical lifestyle, and its upheaval is felt in economic, social, educational, and professional realms. Many countries, including Pakistan, were unable to cope with the devastating pandemic, and when the third wave of COVID-19 arrived, it was clear that a comprehensive backup strategy to combat the pandemic was urgently needed. To cope, the government must make difficult decisions since COVID-19 will not go away quickly. The level of poverty is predicted to climb by 33.7 percent. Many harmful effects have already been noticed in the economy's primary, secondary, and tertiary sectors, including education, health care, and health care. A well-managed and planned strategy plan including all sectors of society and directed by government officials is essential given the current economic upheaval, a weak healthcare system, and a lack of critical health literacy. The purpose of this study is to look at the micro- and macro implications of COVID-19 on Pakistan's socioeconomic and environmental factors. It also addresses the current situation as well as the potential consequences in the future.

**Keywords:** corona virus, economic crisis, Pakistan, socioeconomic impact of covid19

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# INTRODUCTION

## Global Impact

Due to COVID-19's outrage, the entire world suffered in all sectors of life. From February 2020, the crisis has gone global, with substantial cuts in revenue, tax collection, income levels, and production capacities of production units all over the world. A large impact was predicted on global GDP growth [1]. The catastrophe of COVID-19 might affect global GDP between 2.3 percent to 4.8 percent [2]. According to the report by UNCAD, a shrink of 5%– 15% was expected in the FDI (foreign direct investment) [4]. A support package covering up to USD 2.5 trillion is needed to cope with fatal damages of virus [3]. Almost 25 million individuals are at risk of losing their jobs around the world, resulting in a loss of up to USD 3.4 trillion in worker income. As a result, poverty will rise, with nearly 11 million people living on the brink

of starvation. In developing economies, the situation is far worse. Expect the situation to get a lot worse. According to the United Nations Development Program, income shortfalls in developing countries are likely to surpass 220 billion dollars. In a recent World Bank report, it was stated that South Asia's economy would have its worst year in 40 years, with nearly half of the countries falling into deep economic crisis [5,6,7].

## Pakistan Situational Analysis

According to government statistics, the health ministry's report presented in fig. 1 showed that a total of 7,889,741 tests were performed, with 1,290,848 of them confirming the presence of virus in the recipient. 1,252,396 people were able to combat the illness and live, whereas 28,870 people died as a result. At the moment, 9,582 individuals are battling the infection [6].

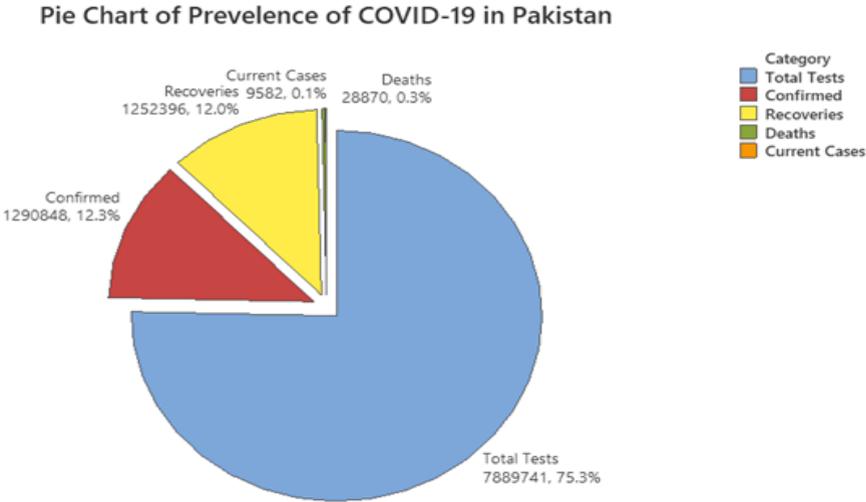


Fig. 1 Government of Pakistan statistics of outbreak of COVID-19 [6]

An insight into the provincial statistics in table 1 showed that Sindh has been hit the most by COVID-

19, with 478,942 confirmed cases, followed by Punjab with 444,119 confirmed cases. There were 180,938



cases reported in KPK, and 108,240 cases in the Islamabad Capital Territory. COVID-19 had a lower impact in AJK, Baluchistan, and Gilgit Baltistan than in other Pakistani provinces, with 34,633, 33,548, and 10,428 confirmed cases, respectively. A total of 465,864 cases recovered fully from COVID-19 in Sindh, while 428,014, 174,334, and 106,973 patients recovered from Punjab, KPK and Islamabad. 10,229 cases recovered from COVID-19 in Gilgit Baltistan, 33,143 recoveries in Baluchistan and 33,839 recoveries in Azad Jammu Kashmir. Currently there are 5,429 active cases in Sindh and 7,649 people have lost their lives to COVID-19 so far. Statistics from Punjab, KPK and Islamabad present 3,048 active cases and 13,057 deaths in Punjab, 697 active cases and 5,907 deaths in KPK, 304 active cases and 963 deaths in ICT. There are now 13 ongoing cases in Gilgit Baltistan, with 186 individuals killed so far, and 42 active cases in

### Pakistan Strategy

COVID-19 had a detrimental effect on Pakistan. However, Pakistan’s government has been actively engaged with different strategies in attempts to cope up with the devastating blows of COVID-19 after it was declared an outbreak by the World Health Organization (WHO). Without extensive testing and screening standards, the virus infiltrated the country’s population via pilgrims and travelers [8,10]. The NPRP (National Preparedness and Response Plan) was produced by the Pakistani government which contained SOPs and guidelines for travelling and international flights [11]. COVID-19-designated hospitals and isolation facilities, early detection, risk communication, and contact tracing were offered

Table 1 Prevalence of COVID-19 by Province [6]

Baluchistan, with 363 casualties. COVID-19 is currently being fought by 49 people, with 745 having met their marker [6,8].

from the national government to help decrease COVID-19 hazards [11,12]. Congregational prayers in religious buildings such as churches and mosques represent a considerable risk of disease transmission therefore, many Islamic regimes, including Qatar, Kuwait, and Saudi Arabia, have imposed a temporary

Province	Confirmed Cases	Active Cases	Deaths	Recoveries
AJK	34,633	49	745	33,839
Baluchistan	33,548	42	363	33,143
GB	10,428	13	186	10,229
Islamabad	108,240	304	963	106,973
KPK	180,938	697	5,907	174,334
Punjab	444,119	3,048	13,057	428,014
Sindh	478,942	5,429	7,649	465,864



ban on congregational prayers, and the Pakistani government followed the same strategy [9]. Hospitals are equipped with resources in an effort to combat the deadly virus, and several hospitals are designated for patients with confirmed or suspected COVID-19. Only one such hospital is operational in Islamabad; Baluchistan has ten such hospitals, and KPK has seven. Punjab, Sindh, AJK, and Gilgit Baltistan each have six, three, and four similar hospitals [8,10].

The rapid spread of COVID-19 was a grave concern and the government of Pakistan deployed possible strategies to mitigate the risks spread of the deadly virus. Western borders closed; international flight operation was temporarily suspended with effect from March 21, 2021. All educational institutions went into closure for three weeks with immediate effect, private and public gatherings including concerts, marriage halls, and conferences were banned which are the concrete acknowledgment of the government’s commitment towards stopping the spread of COVID-19. The government of Sindh announced a relief package of 3 billion under the campaign named “COVID-19 Relief Fund” and the government of Pakistan launched a relief package under the name “Ehsaas Program” which provided for a stipend of Rs 12000 for poor and needy families [13,14].

**Socioeconomic Analysis in Pakistan**

The enormous consequences of the epidemic on all aspects of life have transformed the ways of a typical lifestyle, and its upheaval is felt in economic, social, educational, and professional realms. With an estimated 34 percent reduction in unemployment and a 42 percent decrease in overall income. It was estimated that COVID-19 would cause an economic loss of almost 10% (1.1 trillion PKR) in Pakistan by the end of 2021. Many countries, including Pakistan, devised anti-virus strategies and approaches, which

undoubtedly mitigated the devastating consequences of COVID-19. Despite strong preparedness against COVID-19, many areas were particularly hard impacted by the pandemic. These sectors are described in more detail below [14,15].

**Corporate Downsizing**

According to the Pakistan Bureau of Statistics, 35 percent of the population aged 10 and up had worked prior to the fatal virus's emergence. This accounts for as much as 55.74 billion people. After the onset of COVID-19 and lockdown situation, a decline of 22% was observed. Approximately, 35.04 million people lost their work. The province of Sindh stands the greatest turmoil of COVID-19 as the work rate of the population decreased from 38% to 23%, Punjab and Baluchistan experienced 14% and 11% points decline respectively. However, it lifts the heart to know that recovery has been started and as much as 33% of has reported working again, which means around 52.56 million people regained work, recovery graph shows a V shape (Table 2) [15].

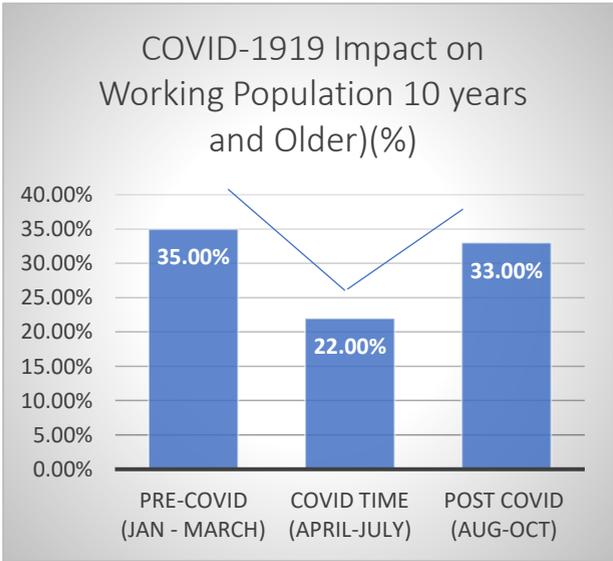


Table 2 COVID-19 Impact on Working Population 10 years and Older) (%) [15]



Furthermore, the table shows that Sindh's rural areas are still more affected by COVID-19. Before COVID-19, 40% of the rural population was employed, but that number decreased to just 28% during COVID-19, and it only rose to 31% post-COVID-19. Sindh's urban life was adversely affected by COVID-19, although it improved by 1% after COVID-19, overall figures showed that 38 percent of the population was employed before COVID-19 23 percent during COVID-19, and 33 percent after the virus, a 5 percent discrepancy. When it comes to urban life, the same

decreasing pattern is observed in Punjab too, during the COVID-19, the work percentage dropped down to 18% which was 34% before it, it rose back to 32% afterwards. However, the overall statistics of Punjab are better than that of Sindh, work percentage dropped to 22% during COVID-19 from 36% and got back to 34% after COVID-19 presenting a pre-post gap of 2%. Other provinces of Pakistan being less populated received less impact and it seems Baluchistan did finest against COVID-19 (Table 3) [15,16].

Province	Urban			Rural			Total		
	Before	During	After	Before	During	After	Before	During	After
Sindh	34	18	35	40	28	31	38	23	33
Punjab	34	18	32	37	25	36	36	22	34
KPK	30	17	29	29	22	28	29	21	28
Baluchistan	31	21	34	34	25	36	33	24	35

Table 3 Province wise Pre and Post COVID-19 employment figures [15]

After the COVID-19 both the urban and rural sectors acquired more jobs, and overall, 33% of the population was employed before the COVID-19 fell to 24% during the COVID-19 and then rebounded to 35%, surpassing the pre-COVID-19 rate by 2%. KPK had a 1% decrease in post-COVID-19 work percentage, which increased to 28% after COVID-19 [15,16].

### Impact on Industry Sector

Figure 2 depicts how COVID-19 wreaked havoc on Pakistan's industrial sector. Labor and worker layoffs increased poverty in the country, with a 20% fall in construction, a 26% reduction in manufacturing, a 17% drop in storage and transportation, a 16% loss in retail and wholesale, an 11% dip in the service sector, and a 5% drop in agriculture, fishing, and farming [15,17].

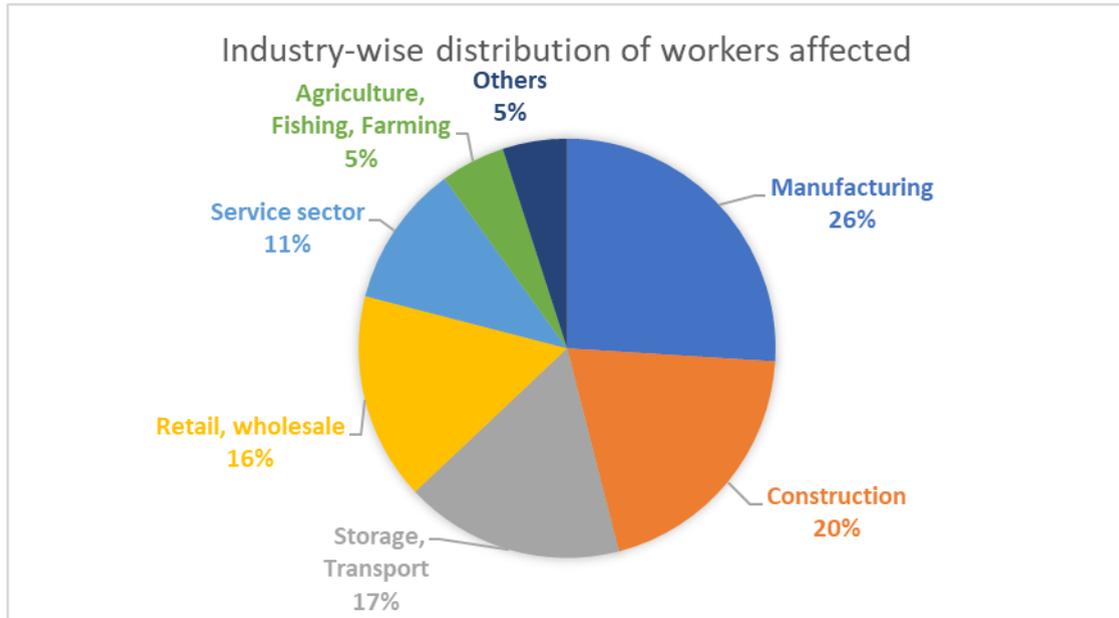


Fig. 2 Industry wise distribution of workers affected [15]

### Food Insecurity and Agriculture

Despite the fact that Pakistan is the world's eighth largest wheat producer, fifth largest sugarcane grower, and fourth largest milk producer, the country continually faces food insecurity. Food security is a critical factor contributing to the severity of the issue, as the disaster that COVID-19 brought shook the world's economies [17]. Countries have tried to protect their people and agriculture from the devastating effects of the pandemic, and food insecurity is a crucial factor contributing to the severity of the issue. Malnutrition has an impact on young children and pregnant women. Only 15% of children in Pakistan have the means to eat the bare

minimum of food, according to the Pakistan Bureau of Statistics [15,16].

"Food security" is defined by the FAO as "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" [16]. A 10% increase in food insecurity has been experienced during the COVID-19 pandemic, in comparison with the HIES2018-2019 report that showed only a 3% rise. 30% of households showed reported moderate food insecurity which was reported 13% in HIES 2018-19 [16,17].

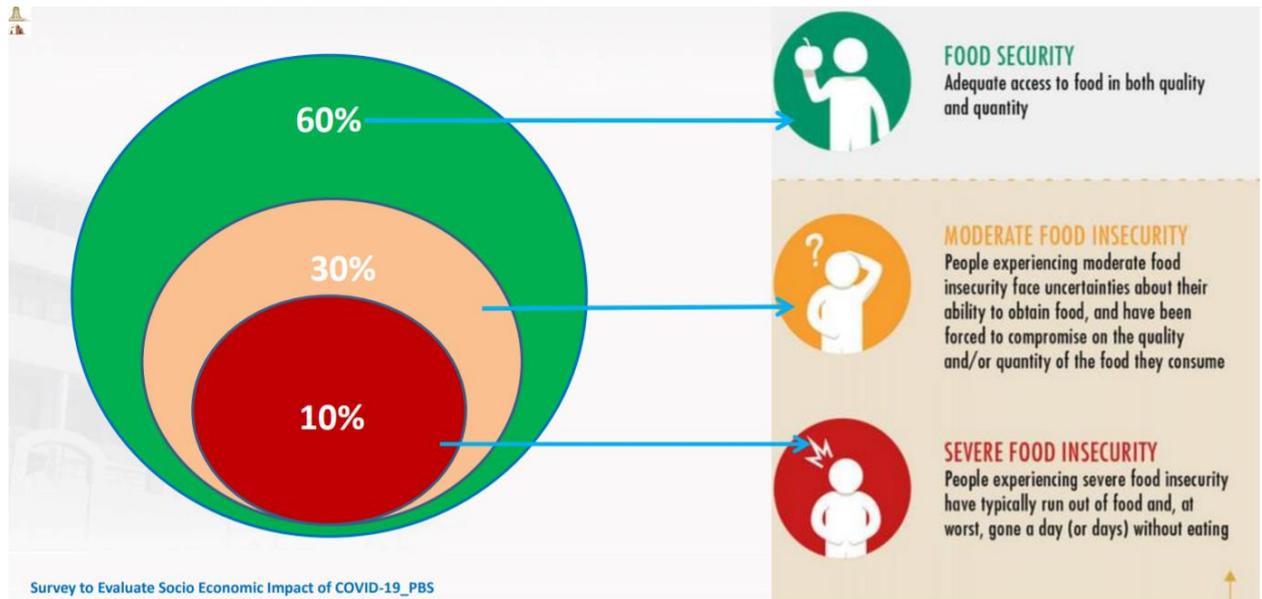


Fig. 3 Food security impact [15]

Meanwhile, 60% of households showed food secured results during the pandemic. The information about quantity, fears, and quality of food people had during the times of COVID-19 and responses show that 59% of people feared not having food, while 60% feared not having healthy and nutritious food to eat. 58% had to eat only a few kinds of meals, while 29% and 30% people had to skip a meal or eat less respectively. A portion as much as 22% ran completely out of food, 17% had less amount of food, so they felt hungry even after having a meal, and 12% had to spend days without food. Pakistan's GDP has always been backed

up by Pakistan's agriculture, still, around 30% of Pakistanis are considered food insecure because they lack access to an adequate food supply. The province of Sindh is the second-largest producer of agriculture in Pakistan, but 46% of the population lacks basic nutritional facilities and people of Sindh are under malnutrition issues [17]. Catastrophic effects of COVID-19 have put shackles to the production capacity by limiting labor and other resources [15,16,17,18]. Details of province wise food insecurity is presented in Table 4 below.

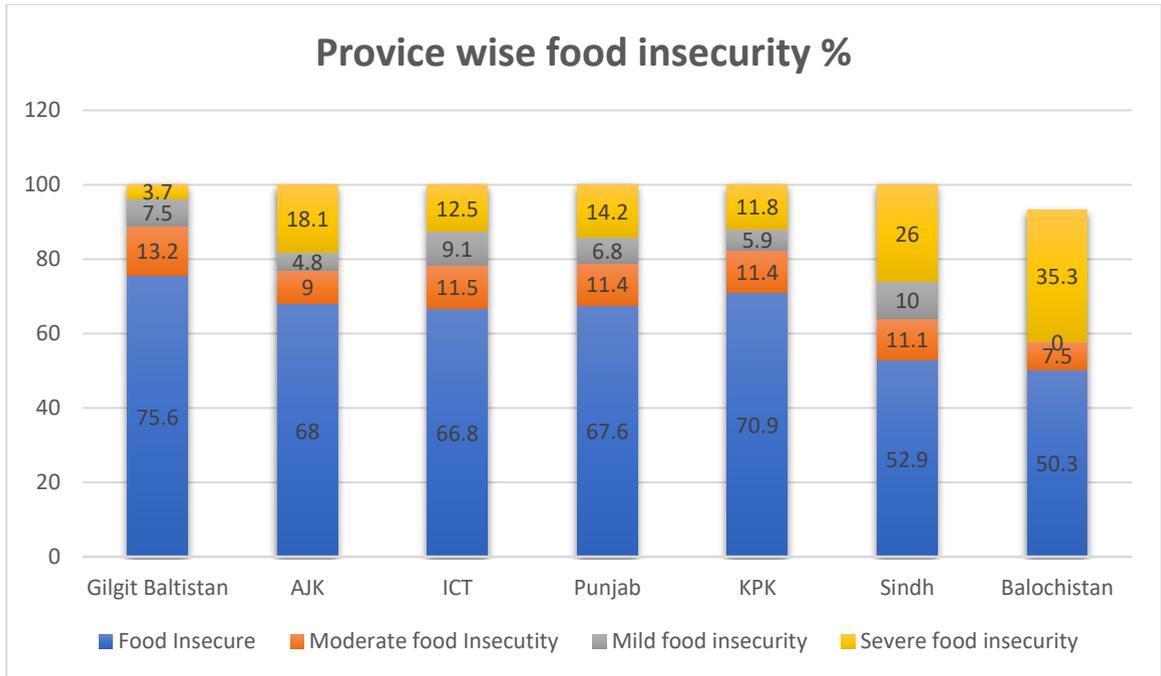
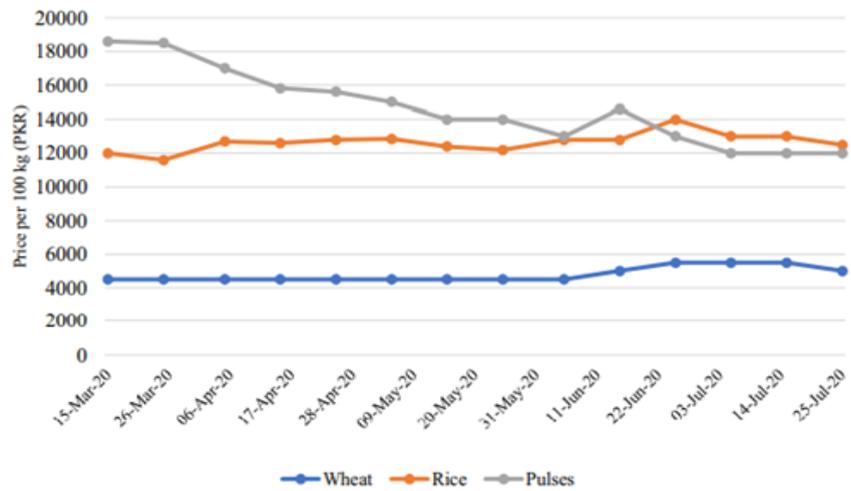


Table 4 Province wise food insecurity [17]

As much as 4% of the country’s GDP comes from five major exports of agricultural products, which are rice, wheat, cotton, sugarcane, and maize [19]. Wheat and rice are the major nutritional source of population and the impacts of COVID-19 have badly affected their production levels which have contributed to significant fluctuations in their prices [19,20]. Poor communities rely on pulses to fulfill their protein needs for their budget constraints to afford red or

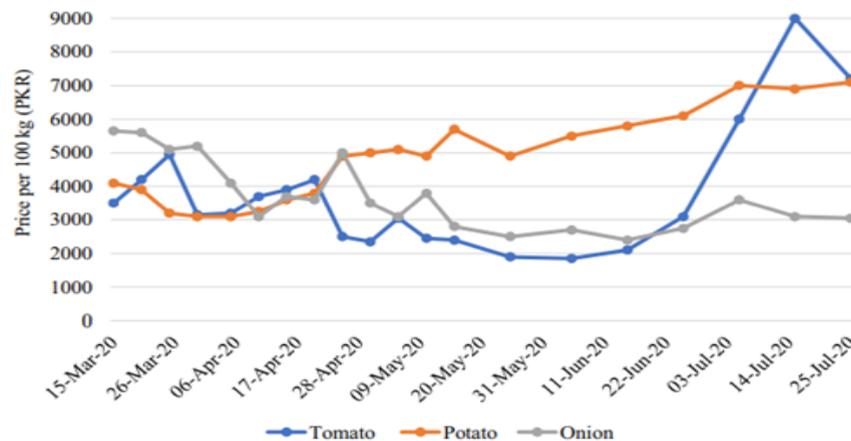
white meat. The variation in prices is given in the Graph 1. It is quite obvious that the price of wheat per 100 kg was observed to be uniform from March until mid-June, and an abrupt increase was observed later on. A 27% price decrease was seen in prices of pulses, price of rice initially experienced an increase by 6.6% followed by a declining trend till June, and an increase was analyzed in June-July again [15,19,20].



Graph 1 Wheat, rice, and pulses price trend [19]

Similarly, the tides have experienced significant fluctuations in prices of fruits and vegetables too (Graph 2). Their limited shelf life already poses a significant challenge and makes them high-risky products. The limited human recourses for harvesting of ripened fruits and vegetables, and lack of resources for transportation to retail markets have caused

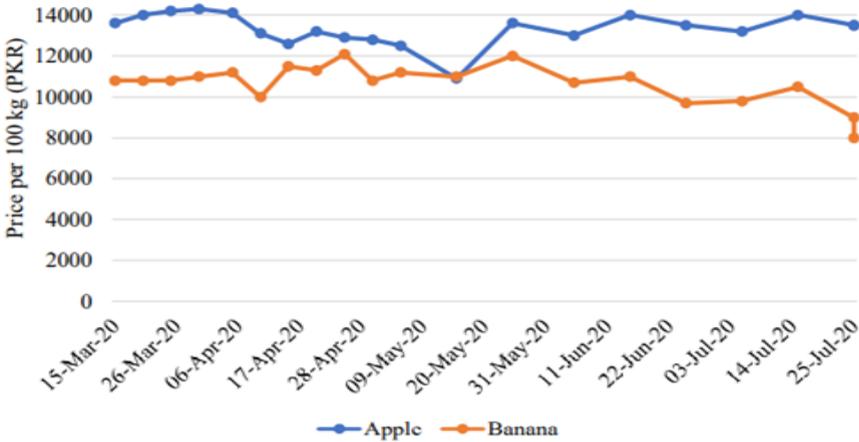
significant damage to agricultural sector. Pakistan makes an annual yield of 1.7 million from production of mangoes and is amongst largest producers of it. The impacts of deadly pandemic are experienced on the harvesting of mangoes too, which usually takes place from mid-May to mid-June in Punjab and Sindh. Temporary suspension of exports between countries also impacted their market [18,19,20].



Graph 2 Tomato, potato, and onion price trend [20]

From the initiation of lockdown to July 2020, the fluctuations in prices of apple and bananas, and vegetables including onions, potatoes and tomato is

shown in graph 3. These items exhibit a seasonal fluctuation in level of production between these months [20,21].



Graph 3 Apple and Banana price trend [20]

### Education Sector

The lethal virus's insurgent attacks also caused damage on the academic sector. Approximately 2.2 billion students from all over the world had their formal education interrupted for a while. Because of the conflict between efforts to contain the virus and prevent its spread and attempts to continue formal education, on-campus activities have shifted to online and virtual learning settings [5, 22]. Pakistan's government demonstrated its dedication to virus prevention by providing immediate regulations for the closure of educational institutions for three weeks. Due to a large-scale change, the allocation of available resources and funding caused serious challenges and grave worries, and some local academic institutions ceased operations entirely due to a lack of funds and

resources. [22] Pakistan is a developing country, so access to contemporary and technological infrastructure has long been a concern. A weighted average of 22% of the population has access to internet services and devices. For students in rural areas, the situation worsens. Only 17% of the population has access to cellphones with internet capabilities, while 54% of the population has only basic functions [23,24].

The country has shifted back from online to partial opening of institutions, and now to completely on-campus learning. On-campus teaching is practices and preventive measures like social distancing, use of masks and sanitizers, and avoidance of hugs and handshakes are being advised. [23,24]



	Percentage of households that have asset					
	Across all groups	Poorest 20	20-40	40-60	60-80	Richest 20
Any remote learning technology	63%	15%	45%	74%	90%	98%
Television	62%	15%	45%	73%	88%	96%
Computer	15%	5%	3%	7%	15%	56%
Internet	12%	0%	0%	2%	9%	50%
Radio	8%	7%	10%	8%	6%	8%
Internet and Computer	8%	0%	0%	1%	4%	40%

Table 5 Ownership of household assets in Pakistan [25]

## Tourism

The onset of COVID-19 has presented various challenges to multiple fronts across the globe, tourism being one. The hostile waves of the deadly virus have struck the tourism industry too, causing it to shut for months [26]. Many practices have been followed in efforts for the revival of tourism in many countries, most countries are still facing challenges to cope up with the menace of COVID-19. In a report published in 2020, the UNWTO stated that tourism is one of the most difficult industries to revive. [26,27] According to WTTC, 75 million jobs are currently in jeopardy around the world. The global economy could lose 2.1 trillion dollars as a result of this massive job loss. For the past eight years, worldwide tourism has contributed an average of 10.4% to global GDP. In recent years, this growth has slowed the global economy [27,30]. COVID-19's extraordinary health risks, economics, and social emergence are being felt all over the world, and it has had a negative impact on the tourism industry [28]. A significant drop in tourism as a result of the widespread restrictions in place around the world, including the complete closing of several internal borders in try to contain the virus. According to the UNWTO World Tourism Barometer, international tourist arrivals decreased by 72 percent from January to October 2020. During this time, a loss of USD 935 billion was recorded, resulting

in 900 million fewer international visitor arrivals. It's ten times more than it was in 2009, when the world was hit by a global economic downturn [27,28,30].

Given the current state of affairs, the UNWTO expects that international tourism will revert to levels seen 30 years ago. There was a rise of 1.5 billion USD (4 percent) in revenues by tourism over the previous year, in the first ten months of 2020 there was a decrease of 72 percent. The Pacific and Asia have suffered the biggest harm, with a decrease of 82 percent in 2019 compared to 2018, which saw a 4 percent increase. A similar impact was felt in the Middle East, which saw a fall of -73 percent from the previous year 2019, which saw an increase of 8% over 2018. COVID-19 had an impact on Africa, Europe, and the Americas as well, with international tourists dropping by 69 percent, 68 percent, and 68 percent, respectively [26,28,31]. Figure 5 represents the major factors that have influenced the decline of international tourism. It is believed that the travel restrictions and lack of coordinated response among different countries remain at top of the list of factors affecting the decline in the international tourist industry. International tourism was badly unset with the ravaging impacts of other factors too, namely the slow virus containment, the flight resumptions, and global economic crisis have also contributed accordingly [30,32].

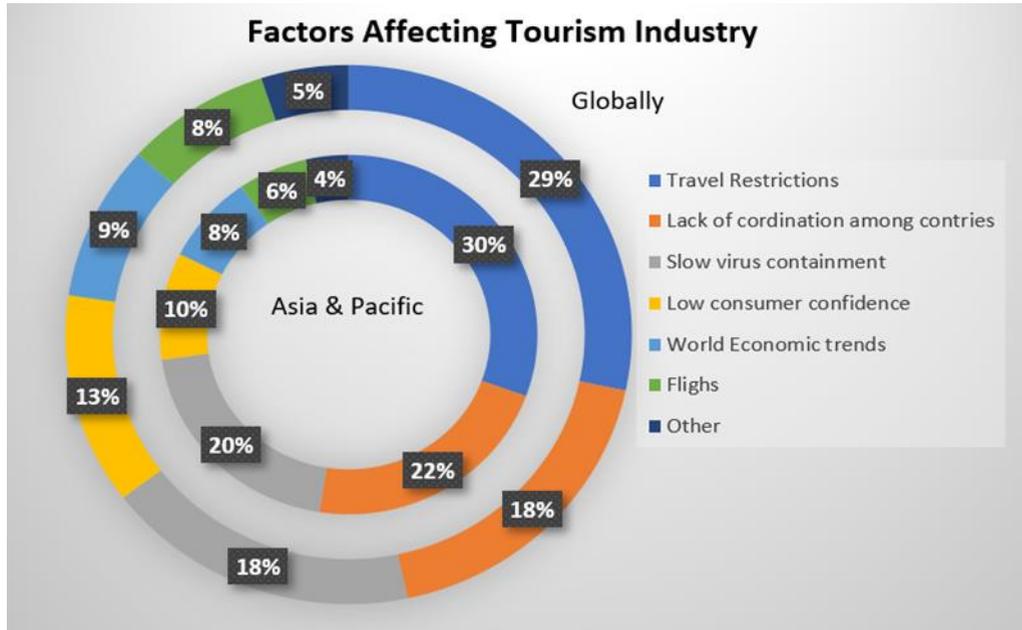


Fig 5 Factors affecting tourism industry [30]

### Impact of COVID-19 on Pakistan's Tourism

Just like any other country in the world, Pakistan's tourism has accepted the catastrophe of impacts of COVID-19 too. A 100 million loss of business was reported by the hotel industry in just one month of February 2020. The bookings of resorts and hotels were also reduced to 40% from January to March 2020, which was reported to be 95%. Substantial losses were experienced in the coming months too. COVID-19 has imposed a 75% reduction in international travel in 2020 [32,33]. Flight operation was put to a halt, and around \$18 million of losses have been reported by Pakistan's Civil Aviation Authority (CAA) March 2020, and it was anticipated that PIA would send workforce on paid leaves [34,37].

Bloomberg, using the Z-score method developed by Edward Altman, published a list of airlines that were under the threat of bankruptcy. It was predicted that PIA could go bankrupt in the coming 2 years due to the sudden jerks given by COVID-19[36]. The graph below shows the number of international from the year 2000. It is quite obvious from the graph that a rapid decline in tourism has occurred since the onset of COVID-19. Further estimation of loss is predicted towards the end of 2020. With a new variant of COVID-19, named the Omicron, the associated risks of reinfections have increased, and further halts might be experienced in the coming weeks. The tourism industry of not only Pakistan but any country around the globe largely consists of small and medium enterprises and entrepreneurs who made their bread and butter via tourists on and off the seasons [27].

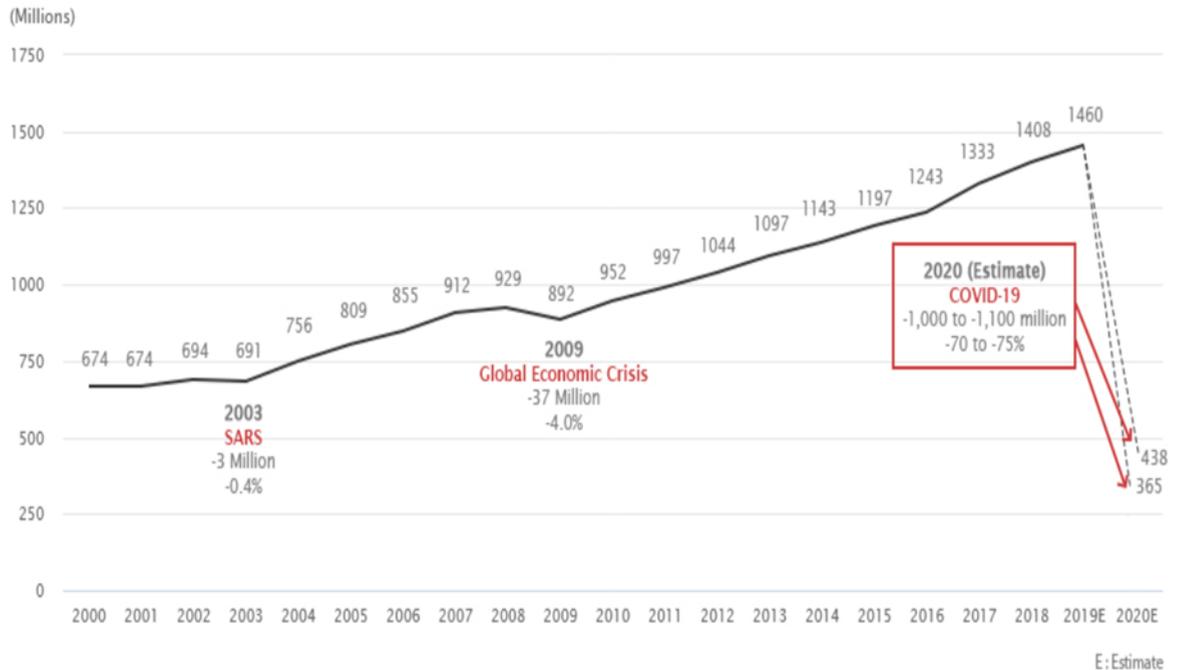


Figure 6: International Flight Arrivals [27]

The prevalence of COVID-19 has badly hit a large number of pastors, tour guides, tour operators, and salaried staff of small, medium, and large hotels that have suffered a steep decline in their incomes. KPK's tourism industry alone lost \$20 million in revenues which resulted in a clean slash of around 260,000 formal jobs. A 100% cancellation of booking is reported by Pakistan's association of bookings for the spring season. These cancellations account for a loss of 10 million USD. In SMEs', 1.5 million jobs are at immediate threat in the tourism industry. This much reduction will greatly impact the foreign exchange earnings which are earned from tourism. A substantial reduction in tax collection will give rise to a reduction of the government's earning [29,35,40].

### Overall Impact on Service Sector

Coronavirus has affected every major and minor economy of the globe because of halts in global activities [37]. The services sector is also facing turbulence in its operations. Out of the total of four

channels delivery of services to customers, three require vicinity for operation and business among buyers and sellers. These are badly affected by COVID-19 social distancing practices [38,39].

Pakistan's services sector has given major inputs towards the GDP of Pakistan and is also a major source of employment [36]. Economic Survey of Pakistan reported in 2018-19 that the services sector of Pakistan has a share of 61.2% in Pakistan's GDP. The growth rate of Pakistan's sector was reported at 4.71% back in 2018-19. The revenues generated by the exports from the services sector back in the year 2019 were \$ 5781 million according to the State Bank of Pakistan. The service sector absorbed 38.6% of the entire labor force (Labor Force Survey, 2017-18). The table below is a translation of the Asian Development Bank's report that portrays an estimated loss of USD 5 billion in the worst-case scenario and USD 16.23 billion in the best-case scenario. These losses consist of subfactors that are related to the transportation facilities, hotels and restaurants, and corporate trade



of the service providers which are running their operations in Pakistan. In the worst-case scenario, corporate trade should face an estimated loss of USD 1.94 billion, and losses of 565.6 million and 253.7 million should be absorbed by the service renders of transportation, hotels, and restaurants. However, the

statistics undergo a significant decrease in the best-case scenario where corporate trades receive an estimated loss of USD 5.54 million. Only USD 0.92 million are to be absorbed by transportation services, and USD 0.67 million for the restaurants and hotel industry [1, 37]

	ESTIMATED LOSS	BEST-CASE SCENARIO
<b>WORST-CASE SCENARIO</b>	Corporate trade, public and personal services	USD 1.94 billion
	Transportation services	USD 565.6 million
	Restaurants and hotels	USD 253.7 million
	<b>TOTAL</b>	<b>USD 5 billion</b>
<b>BEST-CASE SCENARIO</b>	Corporate trade, public and personal services	USD 5.54 million
	Transportation services	USD 0.92 million
	Restaurants and hotels	USD 0.67 million
	<b>TOTAL</b>	<b>USD 16.23 million</b>

A study by the SDPI concludes that 0.36 million SMEs operating in the services sector of Pakistan experienced a decline by 50% in income. 0.76 million SMEs might not survive more than three months, whereas 0.24 million may not survive more than a month on cash flow basis. According to report of SMEDA (2020), overall, 89% of the SMEs are going through financial difficulties and 60% were having problems with selling services and products. [40,41]

The table below is a depiction of results from the report of PIDE. These numbers show Punjab has highest percentage (43.1) of vulnerable employments in the service sector of Pakistan and expected layoff would be 0.30 million. KPK is expected to face the high layoffs of 0.7 million workers out of 41.5%

vulnerable employments. The province of Baluchistan has 32.3% vulnerable employments, and .20 million expected layoffs will be experienced. Sindh stands the most affected province, with 1 million layoffs from total vulnerable employments of 32.8. Provincial governments from each of the provinces should be taking necessary measures in attempts to minimize these threats of layoffs. Unemployment does also have effects on the health and well-being of people<sup>35,42</sup>.

### CONCLUSION

The onset of the contagious viral pandemic COVID-19 produced turbulence in every aspect of life around the globe. Its unprecedented effects have altered the ways of a normal lifestyle, and its disarranging impact is



experienced in economic, social, academic as well as professional realms. Pakistan is a developing economy, and a vast majority of the population is under the waves due to COVID-19. The virus has badly damaged the food and agricultural sector of the country. As with any other walk of life, academia has also accepted severe from the deadly waves of the virus. The tourism industry experienced a full decline in revenues. Restrictions on travel and other factors have devastated the small SMEs, 61.2% of Pakistan's GDP is backed up by the service sector, halts in global activities brought severe damages to the service sector too.

Pakistan's government statistics revealed that almost 34% of the working population had experienced a reduction in employment. These numbers are accounting for more than 5 million of the working population. The province of Sindh stands as the most affected province. The food and agriculture sector of Pakistan was also badly hit. 4% of the country's GDP comes from five major exports of agricultural products, and this percentage is damaged due to COVID-19. Temporary suspension of international trade brought unsettling impacts to the trade of mangoes, apples, and bananas. Unavailability of transport means and human resources for timely harvesting harvest of fruits and vegetables resulted in many price hikes.

The virus's devastation reached the frontiers of the tourism industry too. The bookings of resorts and hotels were also reduced to 40% (USD10 million), and international travel to Pakistan was reported to be declined by 75% in 2020. Loss of \$20 million in revenues in reported by a single province, which lead to the downsizing of around 260,000 formal jobs. A similar catastrophe is observed in the education sector too. The paradigm shift of online learning from on-campus might significantly affect the knowledge of students. Only 17% population has access to the internet and smartphones. Many educational institutes closed due to not having enough resources

and funds. This issue becomes of grave concern for students of rural and backward areas. 61.2% of Pakistan's GDP is backed up by the service sector. 0.36 million SMEs experienced income decline by 50%, .76 million failed survival for three months and .24 million failed survivals for one month. A significant increase by 10% might be the result of loss of employment in rural as well as urban areas of Pakistan, whereas the HIES2018-2019 report showed only a 3% rise. 30% of households showed reported moderate food insecurity which was reported 13% in HIES 2018-19. The revenues of Pakistan reduced to 1/3, exports reduced to half. Pakistan's GDP reduced from 1.145 to -0.935. International travel and tourism shrunk by 75%. A 34% reduction in employment and a 42% decrease in overall income are experienced.

### Future recommendation

A well-coordinated global effort was the evident need to break off the prevalence of pandemics. COVID-19 is not the only pandemic in history. In less than a century, the human race has seen the Spanish flu, SARS, and MERS. There's a dire need for epidemiological and economic analysis of previous pandemics. The Study of the response of mankind and patterns showcased by the past epidemic events could aid in judging the evolution of the current pandemic. It could also potentially lead to factual inferences which might help contain the virus, and devise novel combinations of medicine. The economic analysis might give helpful information to predict the level of disturbances in demand and supply, employment rate, affect in GDPS, FDI, and other economic parameters. The other important need of unprecedented times is to implement comprehensive recovery policies combined with sustainability goals and inclusivity at national and international levels. South Asian region has faced worst effects of the deadly virus, these countries should share information and resources for the betterment of the society and policymaking. Policymakers of developing countries like Pakistan and those of South Asia should seriously understand



the importance of the philosophy “prevention is better than cure”. The results from epidemiological and economic analysis should be considered, and serious steps should be taken accordingly.

**Abbreviations**

ICT	Islamabad Capital Territory
AJK	Azad Jammu & Kashmir
KPK	Khyber Pakhtunkhwa

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## Sustainable urbanization and their challenges in developing countries

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### ABSTRACT

Sustainable Urbanism is a new approach for interdisciplinary planning and design of modern cities, neighborhoods and settlements. Although, the aim of sustainable urbanism enhancing livelihood of all people in equitable and in better manner, creating sustainable urbanism in real world situation is more of theoretical than practical in implementing and sustaining urban development in good manner. Based on final result of research, to sustain urban development in proper manner, proper policies and strategies that consider poor people must be designed, women must be empowered in getting basic service like education, health and employment equally with men, Involvement of private sector and nongovernmental organization also must be strengthen to provide urban service provision in effective manner. Finally reliable good governance and decentralization is crucial for create sustainable Urbanism.

**Keywords:** sustainable, urbanization, challenges, developing countries

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### INTRODUCTION

Sustainable Urbanism is a new approach for interdisciplinary planning and design of modern cities, neighborhoods and settlements. It explores sustainability and urban design in a rapidly

urbanizing world by focusing on the processes that shape the form and function of the built environment in its full complexity infrastructures, land developments, built landscapes, and facilities that collectively make up urban center. Sustainable urbanism need awareness and practice supported by





skills and tools that needed to address real world problems in planning & designing our cities in times of globalization, rapid population growth, economic fluctuations, increased energy demand and global climate change. Over all, objective and effort of sustainable urbanism build better places more livable, more equitable, more energy efficient & ecologically sound, and more prosperous for all people Farr (2007).

Although, the aim of sustainable urbanism enhancing livelihood of all people in equitable and in better manner, creating sustainable urbanism in real world situation is more of theoretical than practical in implementing and sustaining urban development in good manner.

### **Population Growth and prospect of developing countries**

According to UN (2000) report, the world urban population reached 2.9 billion in 2000 and is expected to rise to 5 billion by 2030. In 1950 world population lived in urban areas reached 30%, however, level of urban residents by 2000 will increase to 47 % and projected to 60% by 2030. In less developed countries level of population growth highly increase with average of 2.4 % per year during 2000-2030 and double in time of 29 years .However, level of urbanization is much lower than developed countries and estimated only about 40% reside in urban areas. On the other hand, this proportion much greater than that of 1950 (18%) and expected to increase of 56% by 2030 which similar to developed countries achieved in 1950. The level of urbanization distribution also highly varied between developed and less developed countries .In 1950 only 38% their population living in urban areas out three-quarter of 173 less developed countries .While, in more developed countries from half of 55 countries over 50 % their population reside in urban areas. By 2030, from three-quarter of all countries lived in less developed countries will be reached 49% and the more developed region will be attain 70% from three quarter of the countries.

Over all ,when compare rate population growth of developing countries with developed region it is extremely increasing, however, level of urbanization still lagging behind and highly varied.

### **Role of city in Urban Economy and the informal sector**

The economic contribution of cities between 1960S to late 1980s was not satisfactory. Urban economic growth faster since early 1980's. Cities contribute some 60% of GDP in developing countries and are centers of technological innovation, social change, rapid economic growth, and growing concentration of poverty. Structural economic change of unstable market due to demand and supply composition affects cities economy. Cities have significant role in re-allocations of industrial capacity, creation of job and relative labour market, intensive local competitive production of market power .However, change of economic growth influenced by various social and political change .Inequalities and vulnerabilities also other major problem reflected in urban labour market .Developing countries, in the international level affected by inflation, economic, and political risk, unless adopt policies of liberal and enhanced growth. Type of political system also challenges economic policy of National Governments with respect to global economy. Over all, cities are able to take their own initiative to promote the extension of their industrial capacity and to enhance competitive position United Nations center for Human settlements (1996).

Even though, cities are backbone for urban economy, poverty, rapid economic restructuring, complex socio – political problem, and global economy interference are affect most cities of developing countries so as to enhancing urban economic development in desired manner.

In developing countries women share large proportion and high contribution in the informal sector economy. However, totally absent in formal



economy activity. On the other hand, women's contribution in labour force still increasing. Even if ,women's still smaller than men in industrialized market economy the contribution are 60 % and 31 % respectively , in organization for economic co-operation and development (OECD)countries in 1990.The trend of labour force participation rate of women between 1970 and 1990 rise in North Africa , west Asia , East Asia , and Latin America and the Caribbean , but declined slightly in other region .East Asia known by highest rate of economic activity of women estimated to 59% , while sub-Sharan Africa and South –East Asia estimate with high average rate ranging from 45 to 50 % ILO(2000).

In developing countries the informal sector is great role in urban economy development. However, majority of this sector not get legality from governmental body and especially women face challenge in getting equal opportunity in formal sector and marginalized at all.

### **Economic empowering and enhancing of locally economic development**

According to Jeremy et al.(2006) empowerment defined as `` the process of enhancing an individuals or groups capacity to make choices and to transform those choices in to desired actions and outcomes`` .Empowerment positively associated with field of development including growth ,poverty alleviation ,and awareness of human rights .In other word, empowerment deals minimizing gap between those who have power and not. Empowerment also plays as instrumental role in improving development outcomes. On the other hand, according to Louis et al. (2005) local development not achieved unless supported by proper growth private sector .Enhancing private sector contribute significantly to empower people's especially marginalized and helpless groups having getting opportunity to participate effectively in social ,economic ,and political sphere . In general, there are three principles for enhancing local private sector growth through

integrated approach to local development namely: access to economic infrastructure and services; strengthened human, social, and institutional capital; and a favorable local business enabling environment.

In most developing countries creation of jobs in cities not satisfy people participate in the urban labor force .The livelihood enhancement more focus on individual entrepreneurs and small scale enterprise participate in the formal labor work .While, majority people live in city are poor as a result number of informal sector extremely high which difficult to decline level of poverty in sustainable manner unless the poor households can generate income City alliance (2006).

In developing countries, economic empowerment and enhancement of local development not satisfactory due to less involvement of private sector and majority people economically not good and slum dwellers that not the capacity to have a choice .

### **Gender disaggregation in economy activity and social equity**

According to ILO (2000), cited in UNDP (1994) Human development report great difference between men and women in respect to getting access to asset and social services. In developing countries, level of women's literacy and years of schooling are much lower than men's .Neglecting women's from social services like health and nutrition is a serious problem especially in country like Asia and aggravated in Latin America where women's neglected as a factor of age ,employment, class ,education ,and economic sector which lead to inequality in income difference. Level and rate of open unemployment of especially African women's always double than those of men and currently extremely going on. Women's limited access to employment opportunity especially in the formal sector and there is huge gap between women's and men's in open un employment rate .Although ,female participation high in informal sector, women marginalized from wage employments. In other word absence of getting unfair position of employments, is



a major challenge to boost sufficient and continues income generation .

In general, women in developing countries are totally neglected from getting basic services. The gap between men and women extremely high in level of education, income equality, and poverty.

## URBAN ENVIRONMENT FACILITY AND THEIR CHALLENGE

### Major Urban problems that Challenge sustainable developments

In developing countries factors like push, pull and natural increase factor create over population and huge unemployment rate in cities which leads to poverty. Due to majority of peoples are poor and informal sectors which less contribution for tax revenue, providing basic services like house for people reside under slums and squatter settlements is major challenge for the city manager. On the other hand , transformation of transportation system from traditional to modern way, create un expected traffic problems and changing spatial pattern of city which enhance the need for transportation services and create isolation of home from place of work that significant problem in the city. Finally, environmental problem aggravated in less developed countries, due to poverty and absence of basic urban services as a result waste discharge from congested slum area and Industrial site inter in to river, coastal and underground area affect livelihood of poor people. Deforestation also common problem which facilitated near urban used of timber and domestic fuels Paul and Linda (2005).

In general, in less developed countries problems like poverty, in adequate housing, lack of urban services, transportation problems, and environmental degradation is one of major problem that affect urban

sustainable development and great impact on life of majority of urban dwellers.

### Urban management tools for urban sustainable developments

Urban management tools is a tool used to sustain urban development in good manner .Some of the instrument used to integrate environment with urban planning and management includes : policy, process ,planning and management instrument .Policy instruments serve as guiding principles for urban decision makers through information ,Voluntary , Economic and regulatory instrument . Process instruments deal with doing something through visioning, baseline studies and participatory approach. While planning instrument used variety of methods like environmental profile ,Swot Analysis ,rapid ecological foot print assessment ,monitoring systems and indication and strategic environmental assessment which serve for urban plan development and implementation .Finally, management instruments provide tools to direct and administrative urban planning decision Cities Alliance(2007).

In general to sustain urban development in proper manner adopting different urban management tools is very essential to build and create good urban environment in cities.

### Urban disaster and risk Management

The consequence of environmental deterioration mostly affect the poor .Due to weak economic well being the poor often forced to built shelter in slum ,swamps or near polluting industries area without access to water and sanitation services .Poor people also participate in hazardous occupation with no health and safety legislation. Many cities of developing countries characterized by high rates of infant mortality, limited life expectancy, disability and work related injury, disease, poor quality of life and mental health. The environmental risk also linked



with gendered and women directly affected by this problem and they have the capacity to promote change Robert and Sally(1998).

Many cities in developing countries established in valley area which exposed to floods and related risk. Due to large number of poor people which live in congested and slum area providing basic services that decline disasters and risks is more challenging for governmental body. Therefore, to minimize the problem proper designing of urban disaster and risk management program is very essential to minimize the risk.

### **Urban environmentally built environment**

Building urban environment require much capital and cost than agricultural development .In other word land more valuable when converted from agricultural to urban uses. In the process of urban built environment there are three distinctive circuit of capital accumulation namely :the primary which involve the industrial production of commodities , the secondary involves the production and realization sale into the market in exchange for many of the built environment .The third one concerned with the reproduction of the labor power .Overall production of commodities under capitalism involve joined combination of factor of land ,capital and labor .However, in the production of built environment the land element is incorporated in to the product which is fixed in a particular place Byrned(2001), cited in Harvey(1985).

In general, to built urban environment availability of capital and spacing is very crucial in cities and over all urban land more require capital than rural area.

## **URBAN INFRASTRUCTURE AND EQUITABLE SOCIAL SERVICES FOR SUSTAINABLE URBAN DEVELOPMENT**

### **Access to land and housing services**

Tenure security is serving as protective right against unlawful evictions. However, majority of urban land encroached in informal way which have not legal right to get certificate from governmental body .The majority of this settlers are poor people which live in slum area that not capacity to built civilized house as a result exposed to eviction. On the other side ,getting housing services also major problem in urban center .Housing services intimate relation with access to land , unless an individual right to get access to land ,no opportunity to built house and simply relay on house rent. In contrary, building urban housing services require huge many which majority urban poor people not the capacity to built and purchase respectable house rather only wealth society benefited UN-HABITATE (2003).

Although tenure security serve as guaranty , majority of poor people and vulnerable groups live in cities of developing countries no opportunity of getting access to land and housing services.

### **Access to basic infrastructure and services**

Provision of basic services include clean water, sanitation, waste management ,social welfare ,transport and communications facilities ,energy ,health and emergency services, school ,public safety ,and free open space management facility . Absence of this basic services especially a key factor for poor people living in urban areas. In service provision, local provincial authorities they have responsibility to deliver services regulated by appropriate legislation and standards .However, management capacity, operational and maintenance of infrastructure and



basic services are supported by central government .In addition, private sector and non-governmental organization that high contribution in service provision not inter linked with governmental coordination at the appropriate levels UN Human settlement(2002).

In cities of developing countries, service provision not decentralized at local level in proper manner and only central government plays great role in maintenance and service provision .Ignorance of private sector and non-governmental organization from service provision also another major problem in service provision system.

## **URBAN GOVERNANCE AND ADMINISTRATIVE SYSTEM**

### **Good governance and Decentralization**

Good governance plays great role to keep public interest, initiate urban technological innovation and provide basic services .However, performance of decentralization in developing countries not so much effective and challenged by corruption and budgetary problem. City Alliance (2006) .Decentralization is an institutional arrangement that brings participation and local decision making process which supported by Legislations. Decentralization also help for planning procedure and specifies the level the responsibility to put it. New legal frameworks are developed through decentralization policies, by giving more responsibility at the local level or by assigning more responsible authority that deal with specific urban problems. However, process of implementing urban development project is frequently influenced by national political and economic circumstances in a particular country Meine (2006).

Well managed good governance and decentralization system is welfare of especially for poor people. However, the way this system run in developing

countries not good and majority of poor people not get opportunity ,the system rather complicated by economic and political system.

### **Urban environmental degradation coping strategy**

Most cities of developing countries not established in well position and large number of people live slum area which exposed to environmental degradation .Based on conduct of a network researcher 15 cities of Africa and Asia vulnerable and resilience to climate change in urban areas of developed countries. The research indicate that flooding ,water availability and changing patterns of disease are among serious problems of climate change in urban center .Besides, institutional set up also equivalent factor in determining vulnerability and facilitating resilience. Building resilience strongly depend on the quality of local knowledge, capacity and willingness to act. Urban resilience also strengthens by adoption of proper strategies and strong economic base to cope the shocks and stress of climate change David (2009).

As a result of high climate variability in cities of developing countries and poor people which exposed to environmental risk, building urban resilience is very essential by improving urban infrastructure, good governance, and increasing the capacity of individual and communities.

### **Integrated urban services planning, programming and delivery**

To improving the quality of urban service provision involvement of private sector, specificity, gain experience of small projects ,analyze existing experience ,and bench marking in measuring performance are crucial for improving urban quality .The sense of privatization in the broad tem is empowering participation of private sector in service provision without necessarily changing the ownership utility and in narrow sense changing ownership by selling the share. In specificity scheme



to provide urban services having detailed knowledge of specific sector and experience is very essential. Adopting experience of small scale service delivery improvement tested project applied by countries like China's, taken as best practice approach for other developing countries. In urban service provision performing of advantage of comparative analysis also helps to gain insights, to identify factors in specific and more general way. Finally, taking benchmarking as a measure of performance tool help for comparing companies or utilities on a number of key indicator. Therefore, monitoring the performance and benchmarking are good ways to assess the result Meine (2006).

In general, for improving urban quality, usage of different tool and implementation approach is very crucial to provide integrated urban services provision system.

### **Participation of local communities in urban policy making and implementation**

Participation of local community in policy making and implementation activity helps to give more attention for internal opportunity of development. A citizen a stronger voice in urban policy making and implementation activity, if only associated with importance of local context of development in participatory approach. Supporting of resident participation of both men and women in legitimize policy making can help public policy implementation more efficient and responsive to the needs of the community. The greater involvement of urban residents through participation is becoming more common in urban planning Paul and Linda(2005).

To speed up local development in sustainable manner, giving chance and participating local community in policy and strategies is very essential to empower and to give specific needs.

## **CONCLUSION AND RECOMMENDATION**

Sustainable urbanism is a new approach for interdisciplinary planning and design of modern cities, neighborhoods and settlements. Over all, objectives to build better places of more livable and equitable in all aspect for all people. In developing countries, rate population growth extremely increasing time to time, while level of urbanization moving in slow manner. Economic empowerment and enhancement of local development also less common in developing countries where majority of people are poor and informal sector. Problems like poverty, in adequate housing, lack of urban services, transportation problems, and environmental degradation is one of major problem that affect urban sustainable development. Therefore, to sustain urban development in proper manner :-Proper policies and strategies that consider poor people must be designed ,Women must be empowered in getting basic service like education , health and employment equally with men , Involvement of private sector and nongovernmental organization also must be strengthen to provide urban service provision in effective manner ,and finally reliable good governance and decentralization system also must be established.

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Article

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## Working from home and employee performance in the new normal

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### ABSTRACT

The aim of this study was to determine the effect of working from home on employee performance in the new normal era in Nigeria. The survey research design was adopted and data collection was done through questionnaires. The effect of working from home on employee performance was analyzed using regression analysis method (E-view 7.1 package) to test the hypothesis. The study revealed that working from home has a significant and negative effect on work stress and on work-life balance due to the fact that employees are not able to divide their time between work and personal life. It was opined that this is because employees are used to having fixed working hours. On the other hand, working from home has a positive and significant effect on job satisfaction, with adjusted R square of 0.63 at 5 percent level of significance. Working from home is statistically significant to employee performance; this is indicated by the calculated t-sign of 10.45, 9.64 and 8.49 which are greater than the tabulated t-sign of 1.658 or with their p values of 0.000 which were less than the critical value of 0.05. The study recommended that leaders of organizations need to pay attention to their employees' job satisfaction during their working from home. It is undeniable that working from home can interfere with employees' work life balance and work stress.

**Keywords:** WFH, employee, performance, COVID 19, pandemic, ERA

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### INTRODUCTION

Corona virus disease (COVID-19) ravage the globe and rules on protection like social distancing, wearing a properly fitted mask, and washing your hands or using alcohol-based hand sanitizers frequently were

made to help reduce the spread of the virus (Chinwe Lucia Ochu C.L., Akande O.W., Oyebanji O., Aderinola O., Ogunbode O., Atteh R., Okwor T., Oguanuo E., Ojumu T., Ofoegbunam C., Ebhodaghe B., Joseph G., Ibekwe P. and Ihekweazu C., 2021). The





impact is not just health but a global economic and social shock. Globally, economies were shutdown, schools, places of work, worship centers, market gatherings, tourist attraction sites, and even some public transportation and ordered people to work from home. Many companies also followed government regulation to work from home. However, until now the effect of work- from-home on job performance of employees remains debatable (Baruch, Y., 2001), thus creating a research gap.

Researchers have argued that workers can work at home by utilizing video conference platforms for communication. One of the most observable changes as a result of the COVID19 pandemic is teleworking, telecommuting, or the working from home policy across occupations (Kramer and Kramer 2020). From the problem, the broad objective of this study is to examine the effect of working from home on employee performance in the New- Normal. The specific objectives are to examine the nature of working from home on work-life balance, examine the effect of working from home on work stress, and to examine whether working from home is positively related job satisfaction (employee performance). The basic research questions and hypothesis are geared towards testing the research hypotheses for the purpose of this study was formed accordingly in other to fill the gap. This study will enable organizations both private and public to reassess the design and evaluation of working from home on employee performance in the new normal in Nigeria with intentions of sustaining effective personnel utilization towards efficient service delivery.

## LITERATURE REVIEW

The concept of working from home was first put forward in the 1970s as telework or telecommuting, a new alternative in performing work from different locations (office, home, or another place) using technological assistance (van Meel, 2019) that completely replaced work- related travel (Nilles,

2019). According to Nakrošienė et al. (2019), Teleworking or work from home allows for worker to develop time management skills, flexibility of time and to access an organization’s documents from home, the suitability of having a workplace at home, the possibility to work from home in cases of sickness, and being able to take care of family members. Empirical studies found several outcomes of working from home, such as increased job performance, improved job satisfaction, lesser turnover intentions, and reduced rates of stress (Contreras et al. 2020; Fonner and Roloff 2019; Cohen and Liani 2019; Chung 2018). Many scholars described that teleworking or working from home can support work- life balance positively (Fisher et al. 2019; Ellis and Webster 1988) and negatively (Wessels et al. 2019; Novianti and Roz 2020). The conceptual framework of this research can be seen at Figure 1.

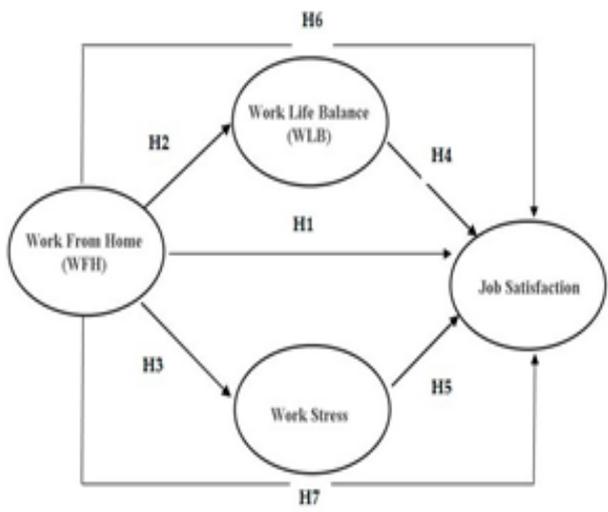


Figure 1. The conceptual model in this research.



## Concept of Work-Life Balance and Work-Stress

Work-life balance is described as achieving a balance between employees' family or personal life and work lives (Jyothi and Jyothi 2012). It is built on the idea that work life and personal life complement each other in presenting perfection in one's life. On the other hand, work stress is a condition that affects the emotions, thought processes, and the thinking process. The gap between the demands of work with existing resources will cause work stress and make people feel more negative and dissatisfied.

### Theory of Job Performance

The theory backing Job Performance according to the founder of the theory is influenced by three main factors: individual, organizational environment, and job demand. The first factor is individual, which consist of the vision, values, philosophy, knowledge, nature, competencies, career path, style and interests of the workers. The second factor is the organizational environment, which consists of the culture and climate, structure and systems, industrial maturity, organizational strategic position, core competencies and the greater context. The third factor is the job demand, which consist of duties, functions and roles of each member in the organization. Dutcher (2017) investigates how working from home influences individual productivity by conducting a real-task laboratory experiment at a US university. He also considers the nature of the job task by distinguishing between creative and boring tasks. He found that working from home increases productivity of individuals when doing creative tasks. Though, he finds that working from home has a negative influence on productivity if the task is too boring. Bellmann and Hubler (2020) find that working remotely has no long-run effect on work-life balance, and that a switch to WFH increases job satisfaction only temporarily. Barrero et al. (2020) estimate that WFH reduced total commuting time among US workers by more than

60 million hours per work day at the height of the pandemic, and that about 35% of this time saved was reallocated to work.

## METHODOLOGY

This section presents the methodology that was be used to carry out the study. The research was conducted in Rite Food Limited, Ogun State precisely. Data obtained from the study were collated and analyzed using inferential statistics.

### Research Design

The survey research method was used to ascertain effect of working from home on employee performance. The design was quantitative to allow for descriptive and inferential analysis. The populations of Rite Foods Limited was found to be six hundred and eighty-six (686) employees of which it consist of 406 senior staff and 280 junior staff. This was established from the Human Resources Department of the organization. The table below shows how the population of the case study looks like.

RITE FOOD LIMITED	POPULATION
JUNIOR STAFF	406
SENIOR STAFF	280
TOTAL	686

Source: Field Survey, 2021

The sample size of the respondent was calculated using simple random sampling technique to select the respondent to the questionnaire. The method is expressed below  $n = \frac{N}{1 + N(e)^2}$  Where N= total number of Employee that constitute the population of the study

E = Level of significance (0.05)



Approximately 253 questionnaires were administered base on the size of the industry.

Junior Staff = 280/686 253 = 103

Senior Staff = 406/686 253 = 150

For this research work, stratified random sampling technique was used to select respondents for this study. Two Hundred and Fifty Three (253) respondents were randomly selected as sample size from Rite Foods Limited in Ososa Ogun State Nigeria

**Model Specification**

The below model was built for the purpose of achieving the best result in this research work. EP = f (WFH)..... {i}

From the above equation

Let Working from Home (WFH) (Independent Variable)

Let Employee Performance = EP be represented with work life balance (WLB), work stress

(WS), and job satisfaction (JS) - Dependent variables. Therefore:

EP= f (WLB, WS, JS)..... {ii}

By substituting equation {ii} into equation {i} the equation becomes

WLB, WS, JS = f (WFH)..... {iii}

The above can be expressed using simple regression equation.  $WLB = \beta_0 + \beta_1 WFH + \mu$

$WS = \beta_0 + \beta_1 WFH + \mu$

$JS = \beta_0 + \beta_1 WFH + \mu$  Where:

WFH = Working from Home WLB = Work Life Balance WS = Work Stress

JS = Job Satisfaction

$\beta_0$  = Parameter Estimates.

$\beta_1$  = Coefficient of Working from Home

$\mu$  = Error Term. Note:

$WLB = f (WFH)$

$WLB = \beta_0 + \beta_1 WFH + \mu$  ----- Model for Hypothesis One

$WS = f (WFH)$

$WS = \beta_0 + \beta_2 WFH + \mu$  ----- Model for Hypothesis Two

$JS = f (WFH)$

$JS = \beta_0 + \beta_3 WFH + \mu$  ----- Model for Hypothesis Three

A' Priori Expectation.

The model above is considered on A' Priori expectation that the explanatory variables would have a positive relationship with the explained variable. Other inferences would be considered from result obtained from the standard error test, the student t distribution, the coefficient of determination (R<sup>2</sup>), F- test and the Durbin Watson autocorrelation result.

**RESULTS AND DISCUSSIONS**

The study presents the results of data collected during the research study. The instrument (questionnaire) used for this study is divided into two sections (section A and section B).





## PRESENTATION & ANALYSIS OF DATA

Data used in carrying out the analysis were collected majorly from raw scores generated from the questionnaire administered to 253 respondents on effect of working from home on employee performance. Out of 253 copies of questionnaires distributed, all were completed and returned. This represents 100% rate of returns. Below are tabulation of analysis of respondent sex, age, marital status, occupations and educational level which belongs to each respondent.

Table 4.1.1: Gender

Respondents	Numbers of Respondent	% of Respondent
Male	147	58.10
Female	106	41.90
Total	253	100

Source: Field Survey, 2021

The findings from table 4.1.1 show the gender of the respondents. 58.10% of the respondents were male, showing that most of the respondents considered as male. 41.9% of the respondents were female. Finally the researchers could presume that in the above percentage, suggests a considerable number to be the female of the population.

Table 4.1.2: Age

Respondents	Numbers of Respondents	% of Respondent
Below 30 years	69	27.27
31-40 years	77	30.43
41-50	60	23.72
Above 50	47	18.58
Total	253	100

Source: Field Survey, 2021

The findings from table 4.1.2 reveal the ages of the respondents, majority of them were in between the ages of 31-40 years (30.43%). While the remaining respondents were between the age of less than 30 (27.27%), the age of 41-50 years (23.72%), and the age of greater than 50 (18.58%).

Table 4.1.3: Marital Status

Respondents	Numbers of Respondents	% of Respondent
Unmarried	159	63.64
Married	92	36.36
Total	253	100

Source: Field Survey, 2021

The findings from table 4.1.3 reveal the marital status of the sample population, 63.64% of the respondents were single, while 36.36% of the respondents of this study were married. It can thus be inferred that majority of the respondents are single.



Table 4.1.4: Educational Status

Respondents	Numbers of Respondents	% of Respondent
O Level	38	15.01
NCE/OND	72	28.46
HND/B.Sc	119	47.04
POSTGRADUATE	24	9.49
	253	100

Source: Field Survey, 2021

The findings from table 4.1.4 above presented information on the educational status of the respondents. It shows that 72 respondents have an NCE/OND degree making up 28.46% of the total respondents. 119 respondents have a HND/Bachelor's degree representing 47.04% of the total respondents. 24 respondents have a postgraduate degree representing 9.49% of the total respondents. 38 respondents have an O' Level certificate making up 15.01% of the total respondents. It is vivid that majority of the respondents have a Higher National Diploma/ Bachelor's degree as their highest academic qualification.

Table 4.1.5: Job Status

Respondents	Numbers of Respondents	% of Respondent
Junior Staff	103	40.71
Senior Staff	150	59.29
Total	253	100

Source: Field Survey, 2021

The findings from 4.1.5 reveal, senior staff representing 59.29% of the total respondents, while 103 respondents are junior staff making up 40.71% which is the lowest numbers.

Table 4.1.6: Tenure

Respondents	Numbers of Respondents	% of Respondent
1-5 years	76	32.34%
6-10 years	55	21.74%
11-15 years	36	14.22%
16-20 years	41	16.21%
>20 years	45	17.79%

Source: Field Survey, 2021

The findings from table 4.1.6 above presented information on the tenure of the respondents. It shows that 76 respondents have used 1-5 years in the organization making up 32.34% of the total respondents. 55 have used 6-10 years representing 21.74% of the total respondents. 36 respondents have used 11-15 in the organization representing 14.22% of the total respondents. 41 respondents have used up to 16-20 years making up 16.21% of the total respondents.

Table 4.1.7: Length doing WFH

Respondents	Numbers of Respondents	% of Respondent
<1 Year	74	29.25%
1-2 Years	121	47.83%
>2 Years	58	22.92%
Total	253	100

Source: Field Survey, 2021

The findings from table 4.1.7 show the length of WFH of the respondents. 29.25% of the respondents WFH <1 Year, 47.83% WFH between the period of 1-2 Years and 22.92% Respondents WFH more than 2 year.



### Test of Hypothesis

We specified in chapter three that effect of working from home on employee performance would be analyzed using regression analysis. The results of the regression analysis are presented below.

### Presentation of Result

#### Hypothesis One

H<sub>0</sub>: That Working from home is not significantly related to work–life balance. H<sub>1</sub>: That Working from home is significantly related to work–life balance.

Table 4.3.1  
 Dependent Variable: WLB Method: Least Squares  
 Date: 11/04/21 Time: 09:39

Sample: 1 - 253

Included observations: 253

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFH	-0.442271	0.067783	10.456208	0.0000
C	0.278794	0.322777	0.863736	0.0035
F-statistic	51.95305	Durbin-Watson stat		1.946637
Prob(F-statistic)	0.000000			

WLB= f (WFH)

$$WLB = \beta_0 + \beta_1 WFH + \mu$$

### INTERPRETATION OF RESULTS

On the basis of the results of hypothesis testing that was carried out, the findings indicated that the proposed hypothesis was accepted because the path coefficients were significant. Working from home ( $\beta_1 = -0.442, t = 10.456 > 1.96, p < 0.05$ ) had a significant and negative effect on work– life balance. The findings above, reveals that the probability of t statistics p-value is 0.0000 indicates that the hypothesis is statistically significant at level of significance (5%); hence p-value of the test statistic is less than alpha value.

The a’p priori expectation for the explanatory variable was (work life balance) was not satisfied. We therefore reject the null hypothesis and simply accept the alternative hypothesis and this means that working from home was significantly related to work–life balance. As reported by the t- statistics.

#### Hypothesis Two

H<sub>0</sub>: That Working from home is not significantly related to work stress H<sub>1</sub>: That Working from home is significantly related to work stress

Table 4.3.2  
 Dependent Variable: WS Method: Least Squares  
 Date: 11/04/21 Time: 09:39

Sample: 1 - 253

Included observations: 253

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFH	-0.452073	0.065947	9.642669	0.0000
C	0.278794	0.322777	0.863736	0.0035
F-statistic	51.95305	Durbin-Watson stat		1.946637
Prob(F-statistic)	0.000000			

WS= f (WFH)

$$WS = \beta_0 + \beta_2 \text{ WFH} + \mu$$

## INTERPRETATION OF RESULTS

On the basis of the results of hypothesis testing that was carried out, the findings indicated that the proposed hypothesis was accepted because the path coefficients were significant. Working from home Likewise, working from home ( $\beta_2 = -0.452$ ,  $t = 9.642 > 1.96$ ,  $p < 0.05$ ) had a significant and negative effect on work stress. The findings above, reveals that the probability of t statistics p-value is 0.0000 indicates that the hypothesis is statistically significant at level

of significance (5%); hence p-value of the test statistic is less than alpha value.

The a priori expectation for the explanatory variable was (work stress) was not satisfied. We therefore reject the null hypothesis and simply accept the alternative hypothesis and this means that Working from home was significantly related to work stress as reported by the t- statistics.

Hypothesis Three

$H_0$ : That Working from home is not significantly related to job satisfaction.

$H_1$ : That Working from home is significantly related to job satisfaction



Table 4.3.3

Dependent Variable: JS Method: Least Squares

Date: 11/04/21 Time: 09:39

Sample: 1 - 253

Included observations: 253

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WFH	0.424559	0.004438	8.496245	0.0000
C	0.278794	0.322777	0.863736	0.0035
F-statistic	51.95305	Durbin-Watson stat		1.946637
Prob(F-statistic)	0.000000			

JS= f (WFH)

$$JS = \beta_0 + \beta_3 WFH + \mu$$

## INTERPRETATION OF RESULTS

On the basis of the results of hypothesis testing that was carried out, the findings indicated that the proposed hypothesis was accepted because the path coefficients were significant. Working from home Likewise, working from home ( $\beta_3 = 0.424$ ,  $t = 8.496 > 1.96$ ,  $p < 0.05$ ) was found to have a significant and positive effect on job satisfaction. The findings above, reveals that the probability of t statistics p-value is 0.0000 indicates that the hypothesis is statistically significant at level of significance (5%); hence p-value of the test statistic is less than alpha value.

The a priori expectation for the explanatory variable was (job satisfaction) satisfied. We therefore reject the null hypothesis and simply accept the alternative hypothesis and this means that Working from home was significantly positively related to job satisfaction as reported by the t- statistics.

## DISCUSSION OF FINDINGS

The first hypothesis confirmed that working from home has a significant and negative effect on work-life balance. Employees are not able to divide their time between work and personal life because they are still used to having fixed working hours. Creating boundaries between work and personal life to create a work-life balance condition is not an easy thing, especially in the pandemic situation that has many restriction policies. A previous study notes that telecommuting work in the digital workplace may offer a strategy for creating flexibility that opens workers' creativity as long as the work-life balance strategies are stretched and implemented well by the workers through organizational support (Lee and Sirgy 2019). Therefore, it is noted that Nigerians needs more time in terms of the nation-wide policy for working from home, with the correct strategies in this digital work setting, innovation could be boosted. The negative consequences may impact on personal well-being, but in terms of productivity and innovation, the opportunity is still wide open, acknowledging the fact that Nigeria is a collective society where a good pace



of teamwork setting in the digital space may open up creative ideas (Valcour and Hunter 2017)

The second hypothesis confirmed that working from home has a significant and negative effect on work stress. The present pandemic forces workers to do extra work, even working overtime because they have to be able to finish the job they were meant to do. Social isolation leads to employees being disconnected from their working environment and triggers work stress. This result is somehow congruent with the study of Gajendran and Harrison (2017), wherein the authors found that the more intense the job load through a telecommuting setting, the more stress was placed on the workers. The study found that in the early stages of the pandemic, the workers were still adapting and the employees were still setting up the correct pace of the work from home policy, wherein the stress levels were still lower; this may prove that in adaptation to the new work setting, the workers may have felt stress but at the same time, the closeness the family members may have reduced their stress levels (Hilbrecht et al. 2018).

The construct of this research was teleporting or working from home related to employees outcomes such as job satisfaction. The third hypotheses result confirmed that working from home has a positive and significant effect on job satisfaction. Employees have the flexibility and autonomy in balancing their work and personal life and tend to increase their job satisfaction. This result is somewhat congruent with the study of Song and Gao (2019), wherein non-fixed workers had more job satisfaction when the organization gave them the flexibility to work from home, as it was reported in the demographic information that the majority of the respondents were classified as being in the early stage of work (tenure less than 5 years) as in the organizational behavior literature they are still regarded as adapting to the workspace, and in the

early stages of their career, people tend to be flexible within tight work deadlines, which may be related to the workload of the non-fixed worker.

## SUMMARY

The major aim of this research is to examine Impact of working from home on employee performance. Specifically, the study sought to achieve the following objectives: To examine the nature of working from home on work-life balance (employee performance); To examine the effect of working from home on work stress (employee performance); To examine whether working from home is positively related job satisfaction (employee performance). In addition to the objectives, chapter one contains the statement of research problem, the research questions, significance of the study, hypotheses, scope and limitations, definitions of terms as well as an operationalization of the research variables used in the study. The following section is an extensive literature and various theories on working from home such as job performance theory and job characteristics model. Section three, focus on the methodology, the researcher adopted the descriptive research design and the survey method. The research instruments used for data collection were the questionnaire. The questionnaires were administered to two hundred and fifty three staff of Food Rite Company Ijebu Ode Ogun State. All questionnaires were retrieved and analyzed. The fourth section involves the presentation and analysis of data which was gotten from questionnaires administered. Descriptive statistics was used for the analysis of the bio-data; multiple linear regression analysis was also used to test all the hypotheses.

## CONCLUSION

This study examined effect of working from home on employee performance in new-normal in Nigeria. Though, working from home in Nigeria was not



regulated well, neither from the government nor the policy itself within the organization, the concept was rarely discussed in the collectivist setting. In this study, the closer a worker is to their family, the more positive is the performance index, which in some areas could increase their job satisfaction, while in the other side, work from home needs to be monitored due to distraction. Work from home can affect job satisfaction in a normal work setting; however, in this study, where workers were forced to work from home, work from had a positive impact on job satisfaction. The study reveals that working from home as the new climate of working for Nigerian workers can maintain their job satisfaction, and it is expected that they commit to their work and fulfill their task accomplishment

## RECOMMENDATIONS

In the light of the findings, the study provides several practical recommendations for the use of the working from home policy in the Nigerian context, especially in terms of the COVID-19 pandemic.

1. The leaders of organizations need to pay attention to their employees' job satisfaction during their working from home. It is undeniable that working from home can interfere with employees' work life balance and work stress.
2. In addition, it is also necessary to pay attention to the workload that must be completed, considering that working in remote conditions has obstacles such as lack of IT support and other jobs that result in a decreasing job satisfaction.
3. Future research needs to re-conceptualize the boundaries of telecommuting work and working from home, as it is visually the same, but in some areas, non-digital workers are not familiar with the concepts of telecommuting work settings. Where possible, dyadic research is encouraged so that the conceptualization of work from home from the perspectives of supervisor or manager can be operationalized.

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## Profitable business ideas in J&K: an overview

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### ABSTRACT

In this paper a delineated the business thoughts in Jammu and Kashmir. The most productive thoughts will assist you with beginning a fruitful business in J&K. Here in this paper, I'm imparting to you few most gainful business thoughts in Jammu and Kashmir. J&K (Jammu and Kashmir) is the northern most State of India offer endless venture freedoms to the forthcoming Investors, as the State has rich assets of Water, Agro, Forests, Herbal and Minerals notwithstanding its unparallel characteristic excellence and consequently enormous potential for interest in the travel industry area. Jammu and Kashmir generally has fabricating enterprises, limited scope businesses, bungalow ventures, agriculture, Butter and curd creation and so on this has discussed in this paper.

**Keywords:** businesses, climates, industrial areas, economy, employment

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## INTRODUCTION

The State of J&K has an extraordinary geology what partitions the State in to 3 particular agro climatic zones viz. the tropical Jammu Division, the mild Kashmir Valley and the chilly parched zone of Ladakh. The State is presented with the normal water assets spread over a region of about 0.40 lacs hectares existing looking like virus water heavy streams, Lakes, Rivers, Sars, Springs, Reservoirs other than around 250 high height Lakes. While the Jammu

Division offers potential for advancement of Warm Water Fisheries, certain zones in the Districts of Kathua, Udhampur, Doda, Rajouri and Poonch likewise offer potential for the improvement of Cold water Fisheries and Mahaseer Fisheries. The Kashmir Valley including Ladakh district offers incredible potential for improvement of Cold Water Fisheries and the native Ichthyofauna. Jammu and Kashmir, known for its excellence has brought a dip into the Startup world. There are numerous new companies that are coming up and demonstrating their valor, disregarding knowing, the negative business





conditions in the state. Kashmir is acclaimed for its food things, tea and flavors, dry organic products and vegetables, painstaking work and so on. The Jammu and Kashmir State is vigorously reliant on its travel industry. The public authority knows about the reality and they are attempting to construct a mechanical climate in the state. They have welcomed driving mechanical places of the country. Be that as it may, the state isn't in an excellent condition as it has confronted extreme psychological oppression dangers and uprisings. Individuals of the state need occupations and since the mechanical interaction is time taking, just Small Scale Industries of Jammu and Kashmir can help. Some of the main businesses of Jammu and Kashmir are: Silk Textile, Carpet-Making and Woolen Textile, Forest-based Industries, Agro-based Industries, Papier Mache, Cement Industry, Industrial Complexes. Silk material is perhaps the most antiquated enterprises of Jammu And Kashmir State. Kashmiri silk-merchandise are famous the world over for their quality, color and conceals.

## Agriculture

Paddy, wheat and maize are the significant yields of Jammu and Kashmir. Grain, bajra and jowar are developed in couple of parts. Gram is filled in Ladakh. The cultivation business in Kashmir has become the shield of rustic economy in the State, giving position offices to the huge number of individuals straightforwardly and by implication. The significant cultivation things are apple, pear, cherry, pecan, almond, peaches, saffron, apricot, strawberry and plum. Around 80% populace of the State relies upon agribusiness.

## Handicraft

Handicraft is the standard business of the State and has been of noteworthy importance given its gigantic work and passage potential. The crafted works business, particularly the floor covering industry, has been a wellspring of liberal unfamiliar exchange. It offers work to about 3.40 lakh specialists.

The amount of mechanical units has also gone up. Both Jammu and Kashmir arrangements have the extent of handiwork business. Handiwork is the customary business of the State and has been of urgent significance given its enormous work and fare potential. A portion of the things of industry are papier-mâché, woodcarving, rugs, cloak making, weaving and so on. The crafted works industry, especially the floor covering industry, has been a wellspring of considerable unfamiliar trade. It gives work to about 3.40 lakh craftsman's. The quantity of modern units has likewise gone up. Jammu has Urban Haats, while a comparable Haat is being charged in Srinagar.

## Tourism

Jammu and Kashmir are known as the crown of India, follows groupings of social, strict spots, insight and visiting works out. It is notable for its transcending snow-clad mountains, sputtering streams, direct and sparkling lakes, bloom meadows, wonderful ranches, and exceptional fauna. Each and every such segment of Jammu and Kashmir has reliably pulled in different travelers from wherever all through the world. The travel industry has created as a critical and one of the genuine supporters of the State's economy. The tourism industry in India is the biggest help industry, with a commitment of 6.23% to the public GDP and 8.78% of the absolute work in India. The travel industry in India is considerable and energetic, and the nation is quick turning into a significant worldwide objective. India's movement and the travel industry is one of them most beneficial enterprises in the country, and furthermore credited with contributing a generous measure of unfamiliar trade. Indian Tourism offers a blend of various societies, conventions, celebrations, and spots of interest.

## Fisheries

The State of J&K has a one-of-a-kind geography which segments the State into 3 specific agro-climatic zones viz. the tropical Jammu Division, the quiet



Kashmir Valley and the cool completely dry zone of Ladakh. The State is offered with the trademark water resources spread over a domain of about 0.40 lacs hectares existing in the condition of infection water heavy streams, Lakes, Rivers, Sars, springs, Reservoirs other than around 250 high height Lakes.

### **Butter and curd production**

Past milk, there is additionally a tremendous neighborhood market comprising families, eateries, lodgings and so on for spread and curd items in Kashmir.

### **Poultry farming business**

The nearby utilization of poultry is high however creation is extremely feeble in Kashmir, thus, permitting an immense outpouring of cash to different states. The nearby business people can stop that to occur while opening more poultry cultivating units in Kashmir.

### **Livestock**

In Jammu and Kashmir, creature farming assumes a huge part as 0.13 percent of total national output (GDP) of the state is contributed by this area. The state has a valuable abundance of animals in type of steers wild ox, sheep, goats, poultry, and so forth the steers and poultry among all the animals are viewed as the main apparatus for the advancement of the rustic economy. The creation of pashmina wraps and other creature items like rugs, cloaks and covers of Kashmir acquire attractive unfamiliar trade for the country.

### **Reusing business**

Reusing zone is yet to get a full enterprising fixation in Kashmir. Despite the closeness of various nearby reusing gathering centers in the valley, there are huge measures of discarded paper, plastic, aluminum containers, metal pieces, etc that foresee tries of

neighborhood business people. You can benefit while selling such recyclables to reusing plants.

### **Sheep farming business**

The neighborhood people in Kashmir eats up around 51, 000 tons of sheep consistently, claims Startup Kashmir. Right around 21, 000 tons are imported from outside the state. What it implies is that neighborhood business people can supersede imported sheep sum with nearby produce while opening sheep farm units transversely over Kashmir.

### **E-commerce solutions**

Countless neighborhood retailers, cafés, lodgings, and endeavors that work in different fields are needing experts who can assist them with promoting the developing pattern of web based shopping. How as an internet business proficient you can offer assistance is by making different online business arrangements, for example, online entries, virtual shopping baskets, SEO, SEM and SMO administrations and so on as needed by their organizations.

## **CONCLUSION**

Presently you know about productive business thoughts in Jammu and Kashmir. Here I have given you the data about the best and top beneficial business before you start any of these businesses, kindly examination in your general vicinity and attempt to discover the taste and inclinations of your kin. At that point start a business and change these individuals into clients.

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## Environmental protection: The use of biosorption of nickel and copper by camel foot (*piliostigma thonningii*) pod in elimination of heavy metals from simulated wastewaters

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### ABSTRACT

Sustainable development stands in three pillars; economic, social and environmental protection. The environment is principal to carry the other pillars. In recent years, the need for safe, efficient and economical methods for the elimination of heavy metals from contaminated waters is topical. This study focused on the use of low-cost alternatives to commercially available activated carbon through camel foot (*Piliostigma thonningii*) pod biomass for the removal of nickel and copper ions from aqueous solution. The study used batch process under various experimental conditions of varying pH, contact time, initial metal ion concentration, particle size, temperature and biomass dose in the analysis. The findings showed that optimum adsorption takes place at pH 4 for both nickel and copper ions with 78% and 72% removal at the optimum time of 4 h and 3 h for nickel and copper ions respectively. The result of the investigation also revealed that the optimum percentage of the ions' removal was obtained at 2.50 g biomass dose, at a particle size of 300 µm, optimum temperature range of 25-30 0C, and initial metal concentration of 50 mg/L. Hence, the survey showed that camel foot biomass is an efficient, economical and inexpensive adsorbent for the removal of Ni<sup>2+</sup> and Cu<sup>2+</sup> in the treatment of contaminated water and wastewater by chemical and allied industries.

**Keywords:** environment, protection, biosorption, nickel, copper, camel foot

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## INTRODUCTION

Sustainable development is the hope for the future economies. All efforts to promote the three pillars of sustainable development such as economic, social and educational efforts as well as environmental protection should be embraced. Environment is an essential component of sustainable development. When the environment, especially the water bodies are polluted (e.g. lakes, rivers, oceans, aquifers and groundwater), it results in grave consequences. Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities.

Water pollution is a major global problem which requires evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). The sixth Sustainable Development Goal which emphasizes clean water and sanitation for all cannot be achieved if the problem of water pollution lacks proper attention it demands. High heavy metal concentration is a major culprit in the problem of water pollution.

Globally, water pollution is a leading cause of diseases and deaths (Goel, 2006), and about fourteen thousand people die daily from exposure to contaminated water (Mandour, 2012; Chaudhry and Malik, 2017). In addition to the acute problems of water pollution in developing countries, developed countries continue to struggle with pollution problems as well. In the national report on water quality in the United States, 45 percent (45%) of assessed stream miles, 47 percent (47%) of assessed lake acres, and 32 percent (32%) of assessed bays and estuarine square miles were

classified as polluted (USEPA, 2007). At the local level here in Nigeria, high mortality in young children in Zamfara state led to confirmation of villages with widespread acute severe lead poisoning in 2010 (Greig et al., 2014; Tirima et al., 2016).

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use such as drinking; and/or undergoes a marked shift in its ability to support its constituent biotic communities as fish. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water (NTP, 2000).

Non-point source pollution (NPS) refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also cited as example of NPS pollution (ATSDR, 2005). Contaminated storm water washed-off from parking lots, roads and highways (called urban runoff) is sometimes included under the category of NPS pollution. This runoff is typically channeled into storm drain systems and discharged through pipes to local surface waters, and is a point source (Majumder et al., 2010).

The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical or sensory changes such as elevated temperature and discoloration. While many of the chemicals and substances that are implicated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration is often the key in determining what is a natural component of water,



and what is a contaminant. This is because high concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna (Goel, 2006). Oxygen-depleting substances may be natural materials, such as plant matter (e.g., leaves and grasses) as well as man-made chemicals. Other natural and anthropogenic substances may cause turbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species (USEPA, 2007). Many of the chemical substances are toxic. Pathogens can produce waterborne diseases in either human or animal hosts. Alteration of water's physical chemistry includes acidity (change in pH), electrical conductivity, temperature, and eutrophication.

Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia (oxygen depletion) and severe reductions in water quality may occur, affecting fish and other animal populations (Selman et al., 2008). Organic water pollutants include detergents, food waste, fats and grease, insecticides and herbicides, a huge range of organohalides and other compounds, petroleum hydrocarbons, lubricants (motor oil), and fuel combustion byproducts, from storm water runoff, tree and bush debris from logging operations, volatile organic compounds (VOCs), such as industrial solvents, from improper storage. Other organic pollutants may also include chlorinated solvents, which are dense non-aqueous phase liquids (DNAPLs) (which may fall to the bottom of reservoirs, since they don't mix well with water and are denser), polychlorinated biphenyl (PCBs), trichloroethylene, perchlorate, various chemical compounds found in personal hygiene and cosmetic products (Wen et al., 2008).

Inorganic water pollutants include: Acidity caused by industrial discharges (especially sulfur dioxide from

power plants), Ammonia from food processing waste, chemical as industrial by-products; fertilizers containing nutrients; nitrates and phosphates—which are found in storm water runoff from agriculture, as well as commercial and residential use, heavy metals from motor vehicles (via urban storm water runoff); and acid mine drainage; silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites (Schueler and Thomas, 2000).

Groundwater pollution is much more difficult to abate than surface pollution because groundwater can move great distances through unseen aquifers. Non-porous aquifers such as clays partially purify water off bacteria by simple filtration (adsorption and absorption), dilution, and, in some cases, chemical reactions and biological activity. However, in some cases, the pollutants merely transform to soil contaminants. Groundwater that moves through cracks and caverns is not filtered and can be transported as easily as surface water. Groundwater pollution is mainly due to the process of industrialisation and urbanisation that has progressively developed over time without any regard for environmental consequences (Longe and Balogun, 2010).

There are a variety of secondary effects stemming not from the original pollutant, but a derivative condition. An example is silt-bearing surface runoff, which can inhibit the penetration of sunlight through the water column, hampering photosynthesis in aquatic plants. The current trend of increasing industrialization is a major source of pollution as industrial effluents containing organic and toxic inorganic compounds are released into water bodies without proper treatment. These heavy metals (e.g. Hg, Cd, Cu, Ni, etc) pose threat to human existence as a result of their toxicity (Kamran et al., 2013).

Effluents from many industries and mining sites contain copper and nickel ions. These effluents when



discharged in nearby river without treatment usually cause pollution of the water body which may ultimately cause problem to human health as well as the total environment. Various methods including ion exchange, chemical precipitation, and electro dialysis etc have been employed and studied to remove heavy metals from aqueous system. However, adsorption method is preferred above these methods because it is very cheap, easy to handle, effective and sludge free. Available literatures revealed that many organic and non-organic materials have been used as adsorbents for the removal of heavy metals, but as far as camel foot (*Piliostigma thonningii*) pod is concerned to the best of our knowledge, no work has been published on its ability as a potential adsorbent for copper and nickel ions from contaminated water and industrial waste water. There has been the quest of research experts for economically and effortlessly accessible adsorbents. Since camel foot pod biomass is readily available around us, it is considered a very suitable and cheap option for use as an adsorbent medium for the removal of heavy metal ions like nickel and copper ions.

## METHODOLOGY

The study used the adsorbent prepared from the camel's foot (*Piliostigma thonningii*) pods sourced within the premises of Federal University of Technology Akure, Ondo State. The pods were harvested from the top of the *Piliostigma thonningii* trees. The pods were opened, the seeds discarded and the pods were washed with distilled water and oven dried between 95-105 °C for three days. The dried pods were then ground to fine particles and sieved using 300 µm, 850 µm, 1.17 mm and 1.70 mm pore sizes (Adebayo *et al.*, 2012). These were stored in air-tight containers and then used for the subsequent batch sorption studies.

Concerning materials used in the study, 1,000 mg/L stock solution of copper ions ( $\text{Cu}^{2+}$ ) was prepared by dissolving 3.803 g of copper (II) trioxonitrate (v) trihydrate in distilled water of 1,000 cm<sup>3</sup> standard

volumetric flask and made up with distilled water. 1,000 mg/L stock solution of nickel ions ( $\text{Ni}^{2+}$ ) was also prepared by dissolving 4.475 g of nickel tetraoxosulphate (vi) hexahydrate in distilled water in 1,000 cm<sup>3</sup> standard volumetric flask and made up with distilled water. Metal concentrations used for the batch sorption studies were prepared by serial dilution from the stocks as required (Onundi *et al.*, 2010).

Furthermore, adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$  by *Piliostigma thonningii* pod powder was studied using methods reported by Aisien *et al.*, 2013. The pH study investigated the effect of pH, on the sorption of metal ions on the biomass, ten (100 cm<sup>3</sup>) samples in duplicate of 50 mg/L of each adsorbate were prepared. Their pH was adjusted to pH of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 by using 0.1 M NaOH and 0.1 M HNO<sub>3</sub>. About 1.0 g of the adsorbent (850 µm in size) was weighed and added to each of the 100 cm<sup>3</sup> of the 50 mg/L simulated water (SW). Each was manually stirred at intervals for 480 mins and then filtered (Anirudhan and Suchithra, 2010). The filtrates were stored in sample bottles already washed and rinsed with distilled water and the residual metal ion concentration in each filtrate was determined using Perkin Elmer Analyst 400 atomic absorption spectrophotometer (AAS).

Contact time study used solution (100 cm<sup>3</sup>) of 50 mg/L of each metal ion, measured into twenty different beakers to study the effect of contact time on the sorption metal ions. The pH of the SW in each of the beaker was adjusted to pH 4 for both copper and nickel ions obtained as the optimum adsorption pH from the previous study. One gram of the adsorbent was added to each solution and was manually agitated. For each metal ion, the experiment was carried out in duplicate for 5, 15, 30, 60, 90, 120, 180, 240, 300 and 360 minutes. The solutions were filtered after each time interval and the filtrates kept for AAS analysis (Ramya *et al.*, 2011).



Temperature study used one gram of the biomass was added to 100 cm<sup>3</sup> of 50 mg/L solution of Ni<sup>2+</sup> and Cu<sup>2+</sup> separately having adjusted the pH to the optimum pH. The mixture was equilibrated in a water bath adjusting the temperature to 30 °C, 40 °C, 50 °C and 60 °C in separate studies. The mixture was stirred and allowed to stay for the optimum time, filtered and the filtrate kept for AAS analysis.

Solutions (100 cm<sup>3</sup>) of 50 mg/L of each metal was measured into eight conical flasks. The pH of the SW was adjusted to the optimum pH and 1.0 g of the following biomass particle sizes (300 µm, 850 µm, 1.17 mm and 1.70 mm) was introduced into it. Each mixture was stirred at intervals for the optimum time at room temperature and was filtered after 3 and 4 hours for Ni and Cu. The residual concentration of Ni<sup>2+</sup> and Cu<sup>2+</sup> in each filtrate was determined in each portion

The data obtained from AAS analysis were subjected to graphical analysis, intra-particle diffusion, pseudo first-order and second-order kinetic models.

## Effect of pH on the Adsorption of Nickel and Copper Ions

The plot of pH profile study for nickel and copper ions is presented in Figure 4.1. The plot showed an optimum binding at pH 4 for both nickel and copper ions. By increasing the pH from 1.0 to 4.0 the percentage ion adsorbed increased from 30% to 77.59% after which the adsorption decreased with increase in pH. The result (Figure 4.1) showed an optimum binding pH of 4. This is in agreement with what has been earlier reported by other researchers. Enos *et al.*, (2011) described that by increasing the pH from pH 1 to 2, the percentage nickel ion removal increased from 30% to 40.12%, while that of copper ion increased from 25.04% to 29.72%. The pH of the solution has a significant impact on the uptake of

heavy metal ions. Adsorption increases as solution pH increases in acidic medium (Kumar *et al.*, 2014).

At pH 3, 55.24% of nickel ion was removed which is a higher percentage and the highest percentage removal of 77.59% was observed at pH 4 whereas for copper ions the increase was gradual, 43.88% of copper ion was adsorbed at pH 3 and at pH 4, the percentage of copper ion adsorbed had risen to 72.85%. At pH 5, there was decrease in adsorption for the two metals. At pH above 5 precipitations occurred for both nickel and copper ions, this is also in agreement with what has been earlier reported by Wang *et al.*, 2005. Lower adsorption recorded at pH below 4 may be as a result of positive charges on the surface of the biomass which led to electrostatic repulsion between the biomass and the adsorbate ions. However, as pH increases, surface H<sup>+</sup> are replaced by OH<sup>-</sup>, increasing negative surface charge favourable to cationic adsorption and result in increased Ni<sup>2+</sup> and Cu<sup>2+</sup> uptake (Enos *et al.*, 2011). The binding of Ni<sup>2+</sup> and Cu<sup>2+</sup> to the biomass is evidently dependent on the pH of the reaction medium. This had been confirmed by others (Wang and Qin, 2005). Furthermore, the decrease in the percentage of adsorption after the optimum pH of the ions could also be due to the weakening of electrostatic force of attraction between the oppositely charged adsorbate and adsorbent which ultimately leads to reduction in the sorption capacity (Baral *et al.*, 2006). This is in addition to the tendency of the ions to precipitate at higher pH.

## Contact Time Study

The effect of contact time on the adsorption of Ni<sup>2+</sup> and Cu<sup>2+</sup> by camel foot pod powder over a period of eight hours is presented in Figure 4.2. It is observed that the amount of metal ions adsorbed increased initially with time for both nickel and copper ions and at 240 minutes equilibrium was reached for nickel ion while that of copper ion occurred at 180 minutes. There was an initial rapid adsorption of the ions in the first sixty minutes after which there was reduction in



the rate of adsorption of the metals` ions from the aqueous solution. The rapidity in adsorption of ions was more pronounced in copper ions in the first 60 minutes than that of nickel ions but later nickel ions uptake had a higher percentage near equilibrium . At equilibrium, nickel ions had a maximum removal of 77%. Equilibrium was reached after 240 minutes after which no ion was further removed but rather there was a decrease in the rate of adsorption as reaction time increased. The adsorption of copper ions also followed the same trend as that of nickel ions but the maximum percentage removal (72.9%) was lower than that of nickel ions at equilibrium. The equilibrium time for copper ions was reached after 180 minutes, after which further increase in contact time did not show any increase in adsorption. The initial rapid removal of  $\text{Cu}^{2+}$  and  $\text{Ni}^{2+}$  has been reported in other studies (Mulu, 2013), confirming what was observed in this current study. The importance of rapid adsorption is relevant in a continuous flow system because it enables an optimum metal uptake

at a high flow rate. The initial increase in metal ions removal before equilibrium may be due to the fact that active sorption sites in the system have a fixed number and each of them can only adsorb one ion in a monolayer (Aljlil and Alsewailem, 2014). This leads to decrease in adsorption as the competition for decreasing availability of active sites increases by the metal ions remaining in solution.

The result of the analysis of variance for nickel and copper ions shows that there is significant difference in adsorption between the contact time of 5 minutes, 15 minutes and 30 minutes, also there is significant difference between the contact time of 60 minutes, 90 minutes and 120 minutes, and there is significant difference between the contact time of 180 minutes, 240 minutes, 270 minutes, 300 minutes, 330 minutes and 360 minutes. There is significant difference between contact time of nickel and copper ions` adsorption.

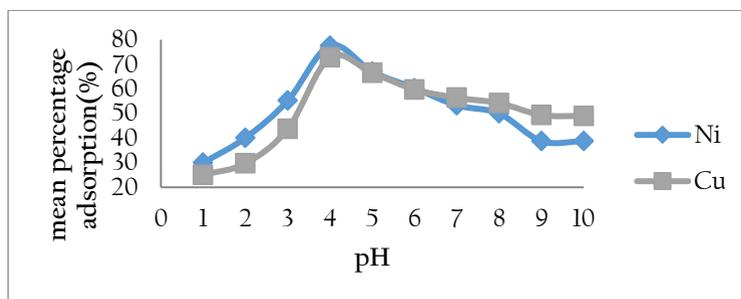


Fig 4.1 Effect of pH on the adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$  by *Piliostigma thonningii* pod powder

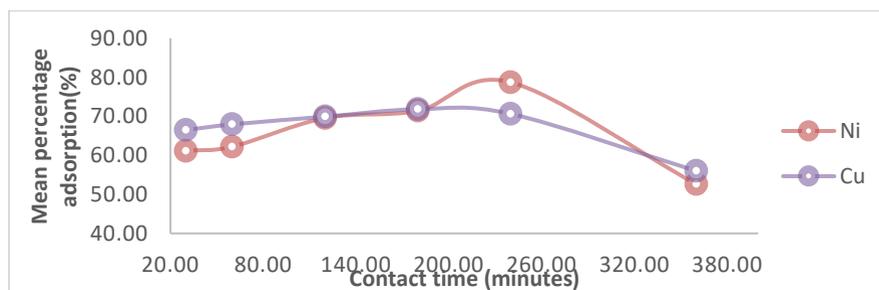


Figure 4.2 Effect of contact time on the adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$  by *Piliostigma thonningii* pod powder.

### Intra-particle Diffusion Model

The Weber and Morris intra-particle diffusion model expressed as:

$$q_t = K_d \cdot t^{1/2} + I \quad (4.1)$$

was used to establish the rate of diffusion of the metal ions into the biomass (Kadirvelu *et al.*, 2005).

Where, I is the intra-particle diffusion constant which is the intercept of the graph, it reflects the boundary layer effect,  $t^{1/2}$  is the time in minutes,  $q_t$  is the amount of sorbate adsorbed and  $k_d$  is the intra-particle

diffusion rate constant. Figure 4.3 shows the plot of  $q_t$  versus  $t^{1/2}$ . The plots showed a partial linear distribution of points. The larger the intercept, the greater is the contribution of the surface sorption in the rate controlling step (Aisien *et al.*, 2013). The linear portion indicates the existence of intra-particle diffusion in the process and the curved portions attributed to bulk diffusion. Meanwhile deviation of the curve from origin is interpreted to be that intra-particle transport is not the only rate limiting step (Das *et al.*, 2013) and that other mechanisms are involved in the adsorption process (Jianlong *et al.*, 2000).

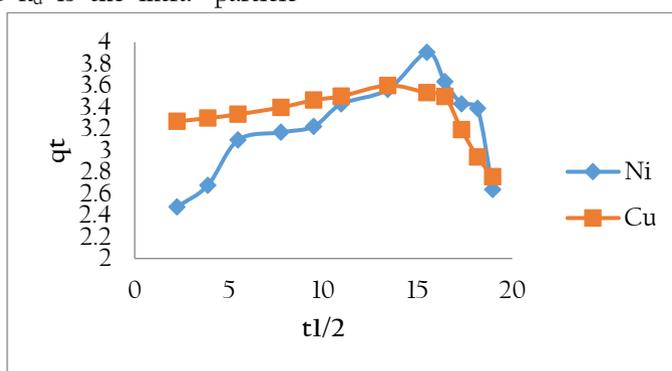


Figure 4.3 Plot of intra-particle diffusion

$$R^2 = 0.190, y = 0.052x + 2.876 \text{ (Ni}^{2+}\text{)}$$

$$R^2 = 0.205, y = 0.031x + 3.520 \text{ (Cu}^{2+}\text{)}$$

$q_t$  = is the amount of sorbate adsorbed

t = time in minutes

### Kinetic Studies of Adsorption of Nickel and Copper Ions

The kinetics studies of nickel and copper ions were undertaken using pseudo- first order Lagergren and pseudo-second order kinetics models. Kinetics is the study of rates of chemical processes and the factors that influence the rates. In order to analyse the adsorption kinetics of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$  on camel foot biomass, the pseudo first order and second order

kinetics models were used to analyse the experimental data.

### Pseudo First Order Kinetics

A simple kinetic analysis of adsorption is the Lagergren equation. The Lagergren equation, a pseudo first-order equation, describes the kinetics of the adsorption process as follows:

$$\frac{dq_t}{dt} = k_1(q_e - q_t) \quad (4.2)$$

Where  $k_1$  is the rate constant of pseudo first-order adsorption, and  $q_e$  and  $q_t$  are the amounts of metals adsorbed per gram of the biomass at equilibrium and at time t (Tshai and Chen, 2010). In many cases, the first-order equation of Lagergren does not fit well for



the whole range of contact times and is generally applicable over only the initial stage of the adsorption (Sarin and Pant, 2006). After definite integration by applying the initial conditions  $q_t = 0$  at  $t = 0$  and  $q_t = q_t$  at  $t = t$ , equation (4.2) becomes

$$\ln(q_e - q_t) = \ln q_e - k_1 t \quad (4.3)$$

A straight line graph of  $\ln(q_e - q_t)$  versus  $t$  suggests the applicability of this kinetic model to fit the experimental data. The graph (Figure 4.4) obtained in the current study suggests that the pseudo first-order

kinetic model is not applicable to this study as can be seen from the non-straight line graph of the kinetics proposing that the rate of adsorption does not depend only on the concentration of a single reactant but on the concentration of both the adsorbent and the adsorbates. Al-Anber and Al-Anber, (2008) also made the same observation while adsorbing iron (III) ions on olive cakes that the adsorption did not obey pseudo-first order reaction perfectly.

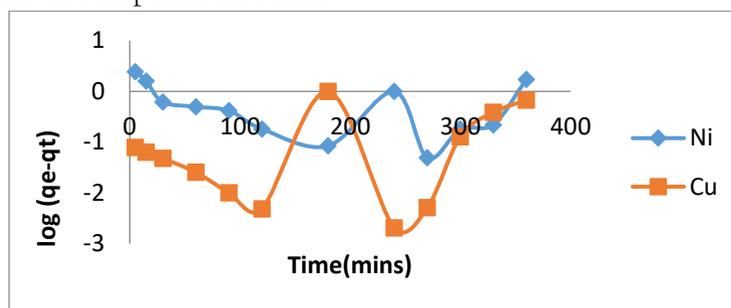


Figure 4.4: Plot of pseudo-first order kinetics

$$R^2 = 0.064, y = 0.001x - 1.617 (\text{Ni})$$

$$R^2 = 0.132, y = 0.001x - 0.130 (\text{Cu})$$

## Second - Order Kinetic Model

The linearized pseudo second-order kinetic model which is expressed as

$$\frac{1}{K_2} \cdot \frac{q_e^2}{q(t)} + \frac{t}{q_e} = \quad (4.4)$$

$$h_i = K_2 \cdot q_e^2 \quad (h_i = \text{initial metal adsorption rate}) \quad (4.5)$$

This equation (4.4) was used to treat the adsorption data of the metal ions uptake by camel foot pod (Ho and Mckay, 2000) and it fitted well with this model as shown in figures 4.5, 4.6 and 4.7. The slope and intercept of  $(t/qt)$  versus  $t$  were used to calculate the pseudo second-order rate constants  $k_2$  and  $q_e$ . The best fit values of  $h_i$ ,  $q_e$ , and  $k_2$  along with correlation coefficients for the pseudo-second-order models are

shown in Table 4.1. The  $q_e$ , experimented and the  $q_e$ , calculated values from the pseudo-second-order kinetic model were very close to each other, and, the calculated correlation coefficients,  $R^2$  were also closer to unity for pseudo-second-order kinetics. These suggested that the pseudo second-order adsorption mechanism is predominant in biosorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$ . Similar processes have been observed in the adsorption of Cu (II), Cd (II) and Zn (II) from aqueous solutions with tannin-immobilized calcined hydrotalcite using batch experiment technique by Anirudhan and Suchthra, (2010) and the adsorption of nickel and chromium ions in dye effluents using activated carbon prepared from groundnut shell by Idris *et al.*, (2012).

The experimental data showed a good compliance with the second-order equation and the correlation coefficients for the linear plots were higher than 0.9 for all the experimental data.

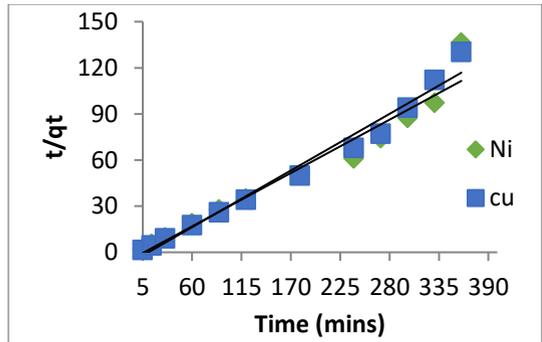


Figure 4.5: Plot of linearized second-order kinetics

of Ni<sup>2+</sup> and Cu<sup>2+</sup>

$$R^2 = 0.951, y = 0.315x - 2.058 \text{ (Ni)}$$

$$R^2 = 0.978, y = 0.334x - 3.746 \text{ (Cu)}$$

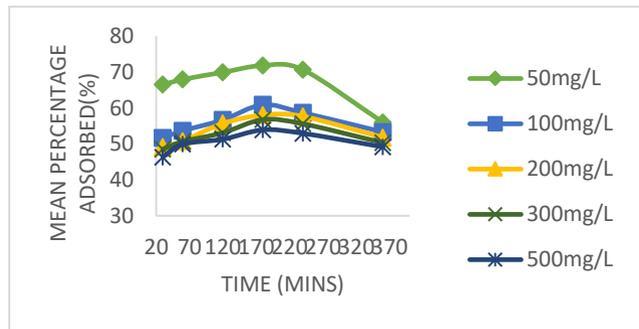


Figure 4.6: Plot of second-order kinetic model of Cu<sup>2+</sup> at different concentrations.

$$R^2 = 0.970; y = 0.354x - 6.996 \text{ (50 mg/L)}$$

$$R^2 = 0.988; y = 0.188x - 1.398 \text{ (100 mg/L)}$$

$$R^2 = 0.984; y = 0.0998x - 0.814 \text{ (200 mg/L)}$$

$$R^2 = 0.997; y = 0.060x + 0.139 \text{ (300 mg/L)}$$

$$R^2 = 0.997; y = 0.039x - 0.084 \text{ (500 mg/L)}$$

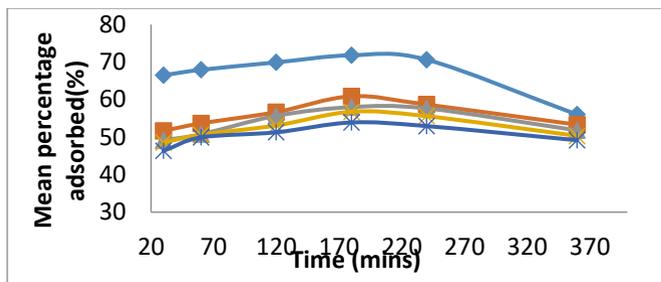


Figure 4.7: Plot of second-order kinetic model of Ni<sup>2+</sup> at different concentrations.

$$R^2 = 0.939; y = 0.360x - 7.485 \text{ (50 mg/L)}$$

$$R^2 = 0.986; y = 0.163x - 1.020 \text{ (100 mg/L)}$$

$$R^2 = 0.992; y = 0.085x - 0.645 \text{ (200 mg/L)}$$

$$R^2 = 0.971; y = 0.057x + 1.123 \text{ (300 mg/L)}$$

$$R^2 = 0.995; y = 0.049x + 0.818 \text{ (500 mg/L)}$$

Table 4.1: Comparison of the Second Order Adsorption Rate Constants and the Calculated and Experimental  $q_e$  Values for Initial Adsorbates` Concentrations.

Initial Adsorbate concentration (mg/l)	$q_e$ experimental (mg/g metal)	$q_e$ calculated (mg/g metal)	$R^2$	$K_2$	$H_i$
Ni <sup>2+</sup>					
50	3.936	3.175	0.951	0.0480	0.4839
100	7.061	6.135	0.986	0.0260	0.9786
200	13.076	11.765	0.992	0.0112	1.5505
300	18.745	17.544	0.971	0.00289	0.8901
500	20.085	20.408	0.995	0.00294	1.2245
Cu <sup>2+</sup>					
50	3.591	2.994	0.970	0.0298	0.2671
100	6.087	5.319	0.988	0.0253	0.9999
200	11.600	10.204	0.984	0.0118	1.2280
300	17.030	16.667	0.997	0.0259	7.1940
500	26.960	25.641	0.997	0.0181	11.906

### Effect of Initial Concentration

Figure 4.8 represents the percentage Ni<sup>2+</sup> and Cu<sup>2+</sup> removed by Camel foot biomass after an incubation period of 4h and 3h respectively for the range of study concentrations of Ni<sup>2+</sup> and Cu<sup>2+</sup>.

The maximum percentage adsorption of Ni<sup>2+</sup> was 78.7% and that of Cu<sup>2+</sup> was 71.8% and these were

achieved at a starting concentration of 50 mg/L. The percentage metal ions uptake decreased as the starting concentrations of the ions increased from the 50 mg/L to 500 mg/L; however the adsorption capacity increased with increase in concentration of the ions. Ion exchange is thought to be the main mechanism involved in the biosorption process and this involves the competition between metal ions and



protons for binding sites on the biomass (Volesky, 2003, Denis, 2000). The lower percentage adsorption of  $\text{Cu}^{2+}$  and  $\text{Ni}^{2+}$  by the camel foot biomass at higher concentration of the metals as observed in the study (as shown in the graphs in the next pages) may simply be due to the metals being present in excess, not due to poor adsorption. The higher percentage of adsorption of  $\text{Ni}^{2+}$  than  $\text{Cu}^{2+}$  might be an indication that camel foot biomass has a higher affinity for  $\text{Ni}^{2+}$  than  $\text{Cu}^{2+}$  (Javaid *et al.*, 2011). Adsorption of lead (II) ions onto activated carbons prepared from the marine green *Ulva fasciata sp.* and commercial activated carbon reported by Jeyakumar and Chandrasekaran, (2014) also followed similar trend of decrease in percentage adsorption as concentration of the metal ions increased. From figure 4.9, as the initial nickel (II) ion concentration increased from 50 to 500 mg/L, the loading capacity of the camel foot pod biomass increased from 3.936 mg/g to 20.085 mg/g. Thus, the adsorption capacity was enhanced with increased initial concentration of the nickel ion. This in agreement with the findings of Ogunleye *et al.*, (2013), while working on the removal of lead (II) ions from aqueous solution using banana (*Musa paradisiaca*) stalk-based activated carbon. From figure 4.10 also, as the initial copper (II) ion concentration increased from 50 to 500 mg/L, the sorption capacity of the camel foot pod biomass increased from 3.591 to 26.960 mg/g. Therefore, it may be concluded that the adsorption capacity was enhanced with increased

initial concentration of the copper ion. This agreed with the observation of Teoh *et al.*, (2013), who worked on the adsorption of lead (II) ions from aqueous phase on carbon coated monolith.

The result of the analysis of variance for nickel and copper shows that there is significant difference in adsorption between the concentration of 50 mg/L, 100 mg/L, 200 mg/L, 300 mg/L and 500 mg/L. There is also significant difference between the concentration study profile of nickel and copper ions.

### Adsorbent Dosage Study

The effect of adsorbent dose on the adsorption of heavy metal ions by camel foot biomass is shown in Figure 4.11. Adsorption profile of the metal ions with various dosages of the adsorbent showed that 0.5 g of the adsorbent adsorbed 73.5% of  $\text{Ni}^{2+}$  and 69.4% of  $\text{Cu}^{2+}$ , while 2.5 g adsorbed 83.4% of  $\text{Ni}^{2+}$  and 76.47% of  $\text{Cu}^{2+}$  of the initial metal ion concentration. The concentration of the metal ions in solution was reduced from 26.5% to 16.7% for  $\text{Ni}^{2+}$  and 30.64% to 23.5% for  $\text{Cu}^{2+}$  by increasing the load of the biomass from 0.5 g to 2.5 g. Hala, (2013), recorded the same observation from the removal of heavy metal ions from waste water using agricultural and industrial wastes as adsorbents. This result suggests that the number of sites available for adsorption increases by increasing the adsorbent dose (Mulu 2013, Kanamadi *et al.*, 2006).

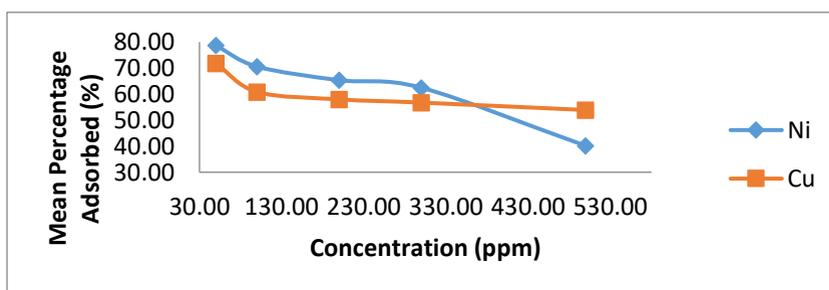


Figure 4.8 Effect of initial concentration on the adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$



$$R^2 = 0.957; y = -0.678x + 81.59 \text{ (Ni}^{2+} \text{)}$$

$$R^2 = 0.669; y = -0.031x + 67.55 \text{ (Cu}^{2+} \text{)}$$

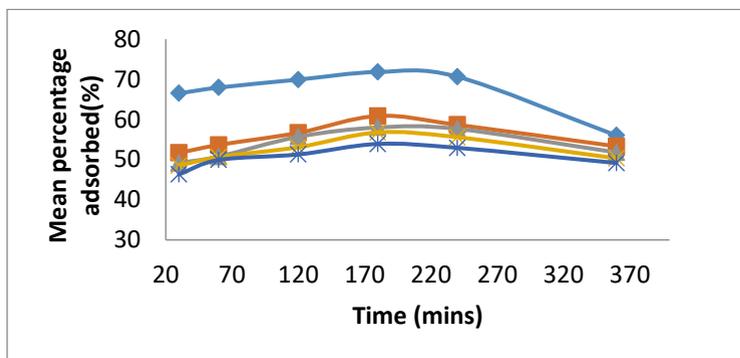


Figure 4.9: Plot of contact time and initial concentration on mean Percentage Adsorption of Ni<sup>2+</sup>

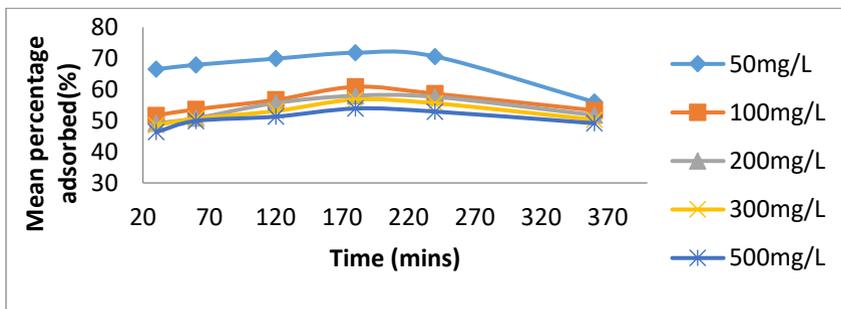


Figure 4.10 Effects of contact time and initial concentration on mean percentage adsorption of Cu<sup>2+</sup>.

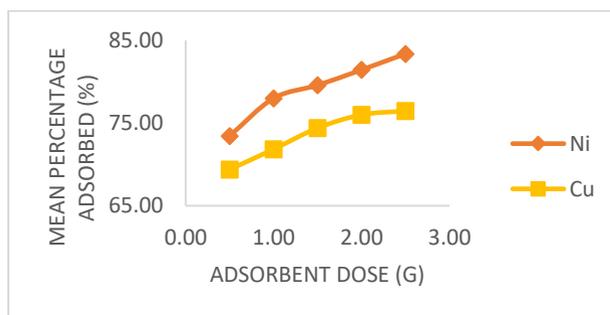


Figure 4.11: Effect of adsorbent dosage on the adsorption of Ni<sup>2+</sup> and Cu<sup>2+</sup>

### Effect of Temperature

The effect of temperature on the equilibrium adsorption of Ni<sup>2+</sup> and Cu<sup>2+</sup> as can be inferred from

figure 4.12 showed that increase in temperature leads to decrease in percentage of metal ions adsorbed. For Ni<sup>2+</sup>, 69.3% was adsorbed at 30 °C while only 35.9% was adsorbed at temperature of 60 °C. Also, for Cu<sup>2+</sup>,



70.9% was adsorbed at 30 °C while 50.6% was adsorbed at 60°C.

This indicates that a lower temperature is more favourable for the adsorption of the ions on the biomass. The trend observed is due to the weakening of the attractive force between metal ions and the adsorbent on the one hand and due to enhancement of thermal energies of the adsorbate on the other hand thus making the attractive force between the adsorbates (Ni<sup>2+</sup> and Cu<sup>2+</sup>) and adsorbent insufficient to retain the adsorbed ions at the binding sites (Jadhav *et al.*, 2007). Babarinde *et al.*, (2012) reported a similar trend for the adsorption of nickel ion,

chromium ion and cobalt ion from aqueous solutions using cocoyam (*Colocasia esculenta*) leaves. Mousavi *et al.*, (2010a) and Nor *et al.*, (2013) reported that the adsorption rate could decrease with increasing temperature, a trend which may be indicative of physical adsorption. The increase in the rate of adsorption by decreasing the temperature indicates that the adsorption process is exothermic (Aisien *et al.*, 2013; Jain *et al.*, 2003). An increase in uptake of ions is expected when the adsorption temperature decreases because adsorption is a spontaneous process (Horsfall and Ayebaemi, 2005).

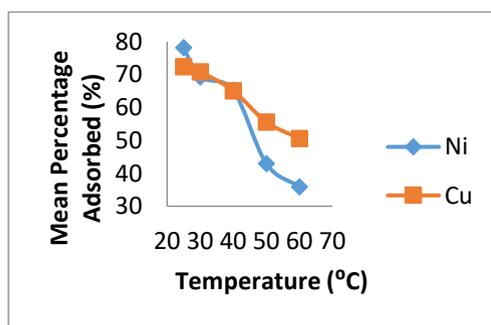


Figure 4.12 Effect of temperature on the mean percentage adsorption of Ni<sup>2+</sup> and Cu<sup>2+</sup>

## Activation Parameters

In general, the rates of chemical reactions increase with an increase in temperature. In the rate law, temperature dependence appears in the rate constant and the dependence of rate constants on temperature over a limited range can usually be represented by the empirical Van't Hoff and Arrhenius equations (Jiwalak *et al.*, 2010):

$$K_d = A e^{-E_a/RT} \quad (4.6)$$

where A is the pre-exponential factor and E<sub>a</sub> is the activation energy and R is the gas constant. From the alternative logarithmic form of this equation:

$$\ln K_d = \ln A - \frac{E_a}{RT} \quad (4.7)$$

E<sub>a</sub> can be obtained by plotting (Arrhenius plot) ln K<sub>d</sub> against the reciprocal of the absolute temperature T. The magnitude of E<sub>a</sub> may then give an indication of whether a physical or chemical adsorption process is in operation. In physical adsorption (physisorption) the interaction is easily reversible, equilibrium is rapidly attained and its energy requirements are small so E<sub>a</sub> is usually not more than 5-40 kJ/mol (Nollet *et al.*, 2003) because usually weak intermolecular forces are involved. However, with chemical adsorption (chemisorption) much stronger bonding forces are involved and E<sub>a</sub> values range from 40-800 kJ/mol (Nollet *et al.*, 2003). In this work, an E<sub>a</sub> of 38.31 kJ/mol was determined from the slope of the plot of ln k<sub>d</sub> versus 1/T for Ni<sup>2+</sup> and that of Cu<sup>2+</sup> was 22.905 kJ/mol.



From this it is inferred that the adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$  by camel foot biomass most likely involves a physisorption process. This is a confirmation of what have been earlier reported by Ashjarian and Mehrdad, (2014).

### Effect of Particle Size

Figure 4.15 showed the effect of particle size on the adsorption of nickel and copper ions by camel foot pod, and from the graph it was inferred that the amount of  $\text{Ni}^{2+}$  adsorbed by the biomass increased from 77.9% to 96.5% by decreasing the particle size from 850  $\mu\text{m}$  to 300  $\mu\text{m}$  while the amount of  $\text{Cu}^{2+}$  increased from 71.9% to 76.9% using the same particle size as in the case of nickel ions. This observation may

be due to increase in surface area as the particle size decreases and the number of active sites increases thereby increasing adsorption (Kumar *et al.*, 2009). The smaller the size of the adsorbent particles, the greater the interior surface area and micro pore volume and consequently more active sites are available for adsorption (Annadurai *et al.*, 2000). However, for larger particles, the pore diffusion resistance to mass transfer is higher and most of the internal surfaces of the particle may not be utilized for adsorption and consequently the amount of metal ions adsorbed is small (Annadurai *et al.*, 2000). Similar results were also obtained by Aisien *et al.*, (2013).

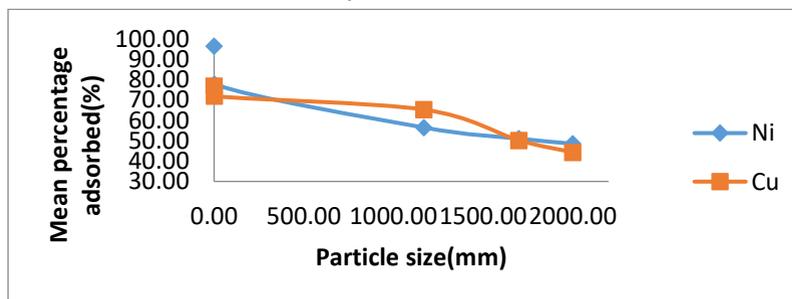


Figure 4.15: Effect of particle size on adsorption of  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$   
 $R^2 = 0.870$ ;  $y = -0.020x + 86.33$

## CONCLUSION

Adsorption of nickel and copper ions from aqueous solutions using camel foot (*Piliostigma thoninigi*) biomass was investigated through batch process. The survey showed that camel foot biomass is an efficient, economical and inexpensive adsorbent for  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$ . The amount of copper and nickel ions uptake increased significantly with increase in pH range from 1 to 4 with the optimum pH being 4. Aqueous solutions of nickel and copper ions with starting concentrations of 50 mg/L gave the best percentage of

adsorption by the biomass moreover adsorption capacity increased with increase in concentration of metal ions.

The temperature profile study showed that both the sorption of nickel and copper ions on camel foot biomass is characterized by a rapid initial adsorption step. 60% of the ions adsorbed were bound in the first 1 h of contact with the biomass. The optimum contact time for nickel ion adsorption was 4 h while that of copper ion was 3 h. The equilibrium data for copper ions are best explained by Freundlich adsorption



isotherm while that of nickel ions followed Langmuir isotherm.

The effect of adsorbent dosage on the adsorption process showed that the adsorption rate increased with increase in biomass dosage due to availability of more surface area for the adsorption. The study of the effect of particle size on the biomass showed that the rate of adsorption increased with decrease in the size of biomass particles.

The adsorption rates of the ions onto the biomass decreased as temperatures increased and this indicated that the process was exothermic and the optimum temperature for the adsorption using this biomass was 25°C. The activation energy for the sorption process of copper and nickel ions were found to be 38.31 kJ/mol and 22.91 kJ/mol respectively. The values of Gibbs free energy  $\Delta G^0$  showed that the reactions were spontaneous. Also, the values of  $\Delta H^0$ ,  $\Delta G^0$  and  $E_a$  all suggested that the sorption of copper and nickel ions onto *Piliostigma thoninigii* pod biomass was by physisorption.

## POLICY RECOMMENDATION

The survey showed that camel foot biomass is an efficient, economical and inexpensive adsorbent for  $Ni^{2+}$  and  $Cu^{2+}$  and can compete effectively with activated carbon.

A policy should be put in place by Nigerian government to implement the use of camel foot pod in the synthesis of composite adsorbent for the treatment of industrial effluents since these materials are cheap and readily available within the country.

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